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Genotype by tillage interactions

in maize (*Zea mays* L.)

by

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INTRODUCTION

During the past 10 years, the percentage of crop acres in the United States which are cultivated by some form of conservation tillage has increased dramatically. The resulting benefits of soil and water conservation, reduced energy and labor inputs, better usage of marginal lands, more timely planting and harvesting, and reduced machinery investment have been expounded frequently. Alternatively, several negative effects which can result have slowed complete acceptance of conservation tillage. This is especially true in the case of no-till.

Researchers in the areas of crop physiology, crop production, soil management, and soil physics have accumulated a considerable amount of research in an attempt to characterize the different cropping environment associated with conservation tillage. Effects of conservation tillage on soil temperature, moisture, bulk density, porosity, nutrient profile, organic matter, and pH have all been examined (Blevins et al., 1983). Resulting effects on germination and emergence, early plant growth, and yield have been studied.

To date, however, no studies exist in the literature in which a large number of maize (*Zea mays* L.) genotypes were examined in different tillage systems, to determine whether genotype by tillage interactions exist. No studies have determined whether unselected genetic material such as a maize breeder might examine responds differently or similarly to elite hybrid material.

This study was initiated to examine the consequences of conservation tillage, especially no-till, for maize breeders. The following objectives were compiled to guide the research problem: (1) to estimate the magnitude of genotype by tillage interactions by growing a large number of genotypes in a no-till and conventional tillage cropping environments, (2) to analyze the associations of traits in no-till, in order to determine whether traits such as early vigor might be more important for no-till than conventional tillage, (3) to determine whether the same or different genotypes are selected in no-till and conventional tillage environments, and (4) to assess the value to maize breeders of using no-till environments in a selection program.

The two tillage systems used were a conventional tillage system with fall plowing, and a no-till system with no tillage or cultivation. The genetic material evaluated included 100 unselected S_1-lines from the maize synthetic BS22(R)C1, 100 unselected S_1-lines from the maize synthetic BS13(SCT)C6, and 60 commercial hybrids from the Iowa Corn Yield Test, regions 1, 2, 3, and/or 5.

LITERATURE REVIEW

Use of Conservation Tillage in the United States

Farmers in the United States are altering the methods by which they till the soil. The percentage of crop production acreage cultivated by conventional tillage procedures declines with each passing year. Crop acreage cultivated by some form of conservation tillage is correspondingly on the increase. Moldboard plows are being abandoned in lieu of reduced tillage implements, which leave a protective residue cover on the soil surface, resulting in reduced soil and water losses. Before quoting any statistics on the switchover, it is necessary to review terminology to be used.

Definitions suggested by Mannering and Fenster (1983) as adopted from the Resource Conservation Glossary (Soil Conservation Society of America, 1982) will be used throughout the dissertation. Conservation tillage is "any tillage system which reduces loss of soil or water relative to conventional tillage; often this is a form of noninversion tillage that retains protective amounts of residue mulch on the surface." The counterpart, conventional tillage, is "the combined primary and secondary tillage operations performed in preparing a seedbed for a given crop grown in a given geographical area." Conservation tillage, by this definition, requires reduced soil or water losses as compared to whatever is considered conventional tillage. Thus, conservation tillage is a blanket term encompassing all tillage practices which conserve soil and water. Mannering and Fenster (1983) break conservation tillage in two principal subcategories--row crop agriculture and small grain agriculture. Small grain agriculture will not be considered in this dissertation. The classes of row crop conservation tillage include: (1) narrow strip tillage, (2) ridge planting, (3) full width, no-plow tillage, and (4) full width, plow tillage. No-tillage is included within the narrow strip tillage classification. No-till is defined as "a method of planting crops that requires no seedbed preparation other than opening the soil for seed placement at the intended depth." The method also is called zero tillage and slot planting.

Trends in tillage use (Table 1), as reported in the publication "No-Till Farmer", were summarized by Christensen and Magleby (1983). Information from the 1983 survey has been added to provide acreages for 1982 (Lessiter, 1983). "No-Till Farmer" uses different definitions for their tillage categories, however. For no-tillage, the immediate seed zone is prepared, and up to 25% of the surface area may be worked. For minimum tillage, limited tillage may be done over the entire field surface. Conventional tillage is where 100% of the topsoil is mixed or inverted by plowing, power tiller, or multiple diskings. These differences in definitions must be kept in mind for the following statistics.

Nationwide, the percentage of total crop acres under conventional tillage decreased 17.7% in the ten year period from 1973 to 1982. The acreage planted to conservation tillage systems, excluding no-till, increased 15.9%; no-till acreage increased 1.8%. In 1973, 82.3%, 15.8%,

Table 1. Use of various tillage systems nationally, 1973 to 1982[a]

Year	Million acres tilled			Percent of total acres		
	Minimum	No-till	Conventional	Minimum	No-till	Conventional
1973	39.1	4.9	203.6	15.8	2.0	82.3
1974	44.1	5.4	210.1	17.0	2.1	80.9
1975	47.9	6.5	217.9	17.6	2.4	80.0
1976	52.1	7.5	223.8	18.4	2.7	78.9
1977	62.6	7.3	227.9	21.0	2.5	76.5
1978	67.5	7.1	223.9	22.7	2.4	74.9
1979	71.5	7.6	220.1	23.9	2.3	73.6
1980	82.7	7.1	210.3	27.5	2.4	70.1
1981	88.0	8.7	205.7	29.1	2.9	68.0
1982	100.3	11.6	204.2	31.7	3.7	64.6

[a]Adapted from Christensen and Magleby (1983), and Lessiter (1983).

and 2.0% of the total acres were planted to conventional tillage, conservation tillage excluding no-till, and no-till, respectively. The corresponding percentages in 1982 were 64.6%, 31.7%, and 3.7%. These percentages are somewhat misleading, as total acres tilled increased from 247.6 million acres in 1973 to 316.1 million acres tilled in 1982. No-till acreage increased from 4.9 million acres in 1973 to 11.6 million acres in 1982. Conservation tillage acreage, including no-till, increased from 44.0 million acres in 1973 to 111.9 million acres in 1982. Conventional tillage acreage began with 203.6 million acres in 1973, then rose to 227.9 million acres in 1977, and declined to 204.2 million acres in 1982.

The 1982 data can be broken down into regions, as suggested by Christensen and Magleby (1983). The Corn Belt region included Iowa, Missouri, Illinois, Indiana, and Ohio. The Lake States region included

Minnesota, Wisconsin, and Michigan. Corn Belt cropping acreage in 1982 was 47.9% conventional tillage, 47.4% conservation tillage excluding no-till, and 4.7% no-till. Lake States cropping acreage in 1982 was 81.9% conventional tillage, 16.4% conservation tillage excluding no-till, and 1.6% no-till. Christensen and Magleby (1983) suggest that the quantity of additional land on which conservation tillage can be practiced without reducing grain yields will limit expanded usage.

In 1982, the Conservation Tillage Information Center (CTIC) was organized to serve as a clearing house for information on conservation tillage. It strives to provide information about conservation tillage to farmers and to organizations which need such information for their daily operations. Their first survey, the "1982 National Survey Conservation Tillage Practices" (CTIC, 1983), provides slightly different statistics than the "No-Till Farmer" publication. The CTIC survey reports for 1982 indicates a total of 392.4 million total cropland acres, of which 84.0 million were conservation tillage excluding no-till, 10.2 million were no-till, and 298.1 million acres were conventional tillage. Respective percentages for the three categories are 21.4%, 2.6%, and 76.0%. The reason for the discrepancy is unclear, as the same reports are being used for the calculations of each. Iowa in 1982 had 25,744,000 total cropland acres, of which 51.8% were conservation tillage excluding no-till, 1.2% were no-till, and 47.0% were conventional tillage, according to the CTIC report.

Conservation will play a major role in farmers' decisions throughout the rest of the century. Conservation of soil, water, energy, time, and labor all have an impact on a profitability, which is a very important overall goal to the farmer. Conservation tillage systems in general should help to obtain this goal; no-till may be the best at conserving of the conservation tillage systems. Major advantages of the no-till system, as listed by Phillips et al. (1980) are as follows:

1. Soil erosion caused by water and wind is reduced;
2. Increased use of marginal lands is possible;
3. Energy inputs are reduced;
4. Timeliness of planting and harvesting is improved;
5. In general, usage of soil water is more efficient, due to reduced soil surface evaporation losses; and
6. The necessary machinery investment is generally reduced.

Accompanying these benefits, however, there are several possible disadvantages.

1. Soil temperatures in spring are generally reduced, relative to conventional tillage. This reduction is due to increased reflectance from the residue cover and higher soil moistures.
2. Greater losses of applied nitrogen may result from the system.
3. Increased microbial activity in the top 5 cm of the soil surface may increase N immobilization.
4. Acidification of no-till soils may affect availability of calcium, aluminum, and manganese. Effectiveness of triazine herbicides may be reduced for the same reason.
5. The soil nutrient profile for phosphorous (P) and potassium (K) is altered.

6. Crop residues may produce a phytotoxic effect on crop growth.
7. A different complex of pests may be present than with conventional tillage.
8. Different sources and methods for fertilizer application and pesticide control may be needed.
9. Other soil physical properties may be affected.

Plant breeders will be unable to exploit the beneficial aspects of the no-tillage system until detrimental aspects of no-till can be controlled. The initial focus of plant breeders, with regard to no-till, will be upon how detrimental aspects of no-till might be solved through genetic manipulation, assuming improved no-till management and production practices would not alleviate the problem. Therefore, this review will not elaborate upon the beneficial aspects of no-till, but will rather discuss the disadvantages. Each of the possible problems outlined above will be discussed separately, and relevant studies cited. Blevins et al. (1983) published a review of the influence of conservation tillage on soil properties which will be cited for several of these topics.

Possible Detrimental Features of the No-tillage System

Soil temperatures in conservation tillage

McCalla and Duley (1946) used wheat straw residue, corn stalk residue, and sweet clover residue to examine the effect of crop residues on soil temperatures. With cornstalks, one-third to one-half of the soil surface was covered, and an average of 1.8°C reduction in soil temperatures at 4 inches depth was noted. Willis et al. (1957) raised soil temperatures with heating cables, and left a mulch cover on the surface. Better emergence, increased early plant growth rate, and earlier maturity were noted on residue covered plots with heated soils as compared to residue plots with no supplemental heating. Willis et al. (1957) postulated that decreased temperatures caused the reduction in grain yield observed with mulch till cropping systems. Burrows and Larsen (1962) applied from 0 to 4 tons/acre of corn stalk mulch on the soil surface, and determined that a $0.7^{o}F$/ton decrease in average soil temperature resulted within that range. Mulch tillage systems used in 1962 often had 1.5 to 2.0 tons of residue per acre.

Lehenauer (1914) used maize seedling growth as a probe to determine that temperatures of 50, 85, and $110^{o}F$ were, respectively, the minimum, optimum, and maximum for maize growth over short periods of time. The study maintained equal air and root temperatures. van Wijk et al. (1959) related the reduction in soil temperature which results from residue cover to Lehenauer's (1914) findings, to explain why mulch tillage systems appear to work better in the southern U.S. than in the northern U.S. It was observed that a $2^{o}C$ difference at the lower end of the temperature range in which maize grows can have a substantial effect on growth rate. However, a $2^{o}C$ difference in the middle or upper portion of the range produces a negligible effect on growth rate.

Jones and Mederski (1963) used one maize hybrid, and Mederski and Jones (1963) used six maize inbreds to examine the effects of soil temperature on maize plant development and grain yield. The hybrid produced more dry matter and grain yield when the soil was heated to optimum temperatures with a heating coil. Inbreds uniformly had more growth on heated plots until 15 July, after which time results were variable. Effects of heating the soil upon final fodder and grain weights were likewise variable for the inbreds. Knoll et al. (1964) used three root zone temperatures, imposed at differing times after planting, to see if a critical time for temperature effects upon early maize growth exists. Dry matter production was consistently greater in warmer soils. A critical time period was not identified. Ketcheson (1968) used two combinations of air and soil temperatures, to determine the effects of two different temperature regimes on plant growth. It was concluded that a significant interaction exists between air temperature, soil temperature, and fertilizer effects, in relation to maize growth. Ketcheson (1968) suggested that an air-temperature-stimulated increase in growth tends to reduce grain yields, whereas a soil-temperature-stimulated increase in growth tends to increase grain yields.

More recently, several researchers have observed reduced soil temperatures as a result of conservation tillage (Griffith et al., 1973; Mock and Erbach, 1977; Gauer et al., 1982; Wall and Stobbe, 1983). Griffith et al. (1973) observed reductions of 3.8^{o}C in mean soil temperature at two locations when comparing a no-till system with a conventional tillage system with fall plowing. The temperatures were measured at a 10 cm depth; means were calculated over the first eight weeks after planting for 1969 and 1970. Mean plant heights at eight weeks after planting were the shortest in no-till, and tallest under conventional tillage with fall plowing, at those same two locations. Similar findings were reported by Mock and Erbach (1977).

Reduced soil temperatures have been demonstrated to retard early plant growth. No-till and other conservation tillage systems have been demonstrated to cause a reduction in soil temperatures. Almost certainly this reduction in soil temperature has a detrimental effect in environments with below optimum soil temperatures.

Nitrogen losses in no-till

Opportunities to incorporate surface applied nitrogen fertilizers below the residue layer of a no-till system do not exist. When nitrogen fertilizers are broadcast on the soil surface, significant N losses can occur via ammonia volatilization. Losses due to volatilization of up to 59% of the applied N have been documented with surface application of ammonium salts in a forage production situation (Hargrove et al., 1977). Incorporation of N fertilizers below the soil surface essentially stops N losses due to volatilization. Numerous soil and environmental factors, in addition to the nitrogen source, determine the amount of N loss (Mengel et al., 1982). Without a method for incorporation, surface application of urea fertilizers has been shown to be highly inefficient (Mengel et al., 1982; Touchton and Hargrove, 1982).

Due to the increased soil moisture which generally results from a no-till system, loss of nitrogen by denitrification is often greater in no-till field. Rice and Smith (1982) demonstrated ratios of N_2O evolution rates in no-till relative to conventional tillage ranging from 1.5 to 77. Anerobic conditions are more likely to occur in no-till than conventional tillage during rainy weather. Populations of denitrifying bacteria may be several fold greater in the presence of a surface mulch

(Doran, 1980). For these reasons, excessive denitrification losses on poorly drained soils may reduce the chances of successful no-till crop production.

No-till systems tend to have more macropores, due to earthworm channels, than conventionally tilled soils. Because soil water content is greater in no-till, the smaller pores are already filled with water. Consequently, rainfall is channeled through the macropores. For the month of June in 1973, Tyler and Thomas (1977) demonstrated losses of nitrate, via leaching, of 14.7 kg/ha for no-till, and 4.0 kg/ha for conventional tillage, on a soil in Kentucky. In general, increased nitrate loss due to leaching was associated with the increased leachate volume obtained with no-till.

Nitrogen immobilization in no-till

Microbial activity is significantly greater in the upper 50 to 75 mm of the soil surface in no-till than in the corresponding portion of the soil profile in a conventionally tilled field. The decomposing residue provides a food source for the microbes. For these reasons, N immobilization has been observed to be about twice as large on no-till than on conventionally tilled soils. In a 3-year study in Kentucky which used fertilization rates of 84 kg/ha of broadcast N, 42% of the fertilizer was immobilized in no-till, and 28% in conventional tillage (Blevins et al., 1983). Immobilized N is not lost, but reduced availability of N may contribute to reduced grain yields, especially at low levels of applied N.

Soil acidification under no-till

No-till systems have been observed to produce a rapid drop in soil pH (Blevins et al., 1983). At a depth of 0-5 cm, the pH was 1.0 units lower in no-till than in conventional tillage (4.8 vs 5.8), after ten years of continuous corn production, using an N fertilization rate of 168 kg/ha. Soil acidification was shown to be strongly influenced by addition of N fertilizer; the problem would be less severe with lower N fertilization rates.

Due to the lower pH, a decrease in exchangeable calcium and an increase in exchangeable aluminum and manganese result. Nutrient stress and plant injury were observed, presumably due to micronutrient deficiencies or toxicities (Blevins et al., 1983).

An acidic soil surface also causes rapid deactivation of the triazine herbicides commonly used in no-till corn production. Therefore, reduced weed control may result from the lowered pH. Application of lime was shown to be an effective practice for controlling soil pH in a no-till system (Blevins et al., 1983).

Potassium and phosphorous profiles under no-till

Potassium (K) and phosphorous (P) fertilizers are generally applied on the soil surface in a solid formulation. Under a no-till system, movement into the soil would necessarily be by water and diffusion. Blevins et al. (1983) observed that K was concentrated in the top 0 to 5 cm in no-till systems, whereas conventional tillage systems had a more uniform distribution throughout the upper 30 cm. Both systems had equal amounts of exchangeable K in the top 30 cm.

Erbach et al. (1980) measured P and K on tillage plots maintained five years in continuous corn. Concentrations of K in the 0 to 3 inch depth were highest on the no-till plots. In no-till, the greatest concentration of P was in the 0 to 3 inch depth range, whereas for conventional tillage, the greatest concentration of P was between 3 and 6 inches.

Due to the lack of incorporation, P and K, which are applied to the surface as solids, are more concentrated near the soil surface of no-till fields than in conventional tillage systems. Uptake of these nutrients is not necessarily affected by concentration gradients, and is dependent upon where root proliferation occurs.

Phytotoxic effects of crop residue on maize growth

Plow and no-tillage practices were used by Barber (1971) to study the effect of tillage and residue on maize root distribution and morphology. Residue treatments consisted of: (1) all residue removed, (2) residue returned, and (3) double residue returned. Maize residue depressed the amount of root weight per unit volume of soil significantly in 1969. Conventional tillage plots with residue removed had the greatest weight and length of roots per unit soil volume. By the same criteria, normal residue plots with conventional tillage had somewhat less roots, and double residue plots had the least roots.

The effects of residue and residue extracts on maize germination and early seedling growth has been examined by Yakle and Cruse (1981, 1983). Fresh residues that contacted plant roots inhibited root growth more than residues which were incubated (Yakle and Cruse, 1981). Seeds germinated in aqueous extracts from maize residue incubated without soil reduced root growth 61% compared to the tapwater check treatment. Soil incubation of the residue reduced the inhibitory effects of the extracts. Phytotoxins from maize residue were not inactivated after passage through a column of sterilized soil. Guenzi et al. (1967), used seedling growth to monitor phytotoxicity, and determined that extracts from maize residues remained phytotoxic through 22 weeks of natural decomposition. Bhowmik and Doll (1982) applied residues from 10 different plant species, plus a no residue treatment, to two tillage treatments. No-till maize with maize residue resulted in the lowest final plant populations of any of the combinations. Maize grain yields were also lowest on the plots with maize residue. Control plots with no residue produced a final plant population of 29,700 plants/ha, whereas plots with maize residue produced a final plant population of 19,300 plants/ha. Grain yields were reduced from 5,558 kg/ha on the control plots, to 2,969 kg/ha for the maize residue plots. Maize residue dry matter, as measured the previous fall, was 10,965 kg/ha.

Pest complexes in no-till

Mock (1982) listed foliar diseases as the most potentially dangerous diseases in no-till systems. Anthracnose (*Colletotrichum graminicola*), northern corn leaf blight (*Helminthosporium turcicum*), eyespot (*Kabatiella zea*), southern corn leaf blight (*Helminthosporium maydis*), and Goss' bacterial wilt (*Corynebacterium nebraskense*) all may be greater problems in no-till than in conventional tillage if the surface residues serve as an inoculum source. Other diseases may be problems in specific geographical areas. Mock (1982) states that the incidence of common stalk rot may actually be lowered on no-till due to increased soil moisture. This effect may be negated by foliar disease induced stress.

Kuhlman and Steffey (1982) reported that severity of insect infestations may be related to residue cover, as well. Insects demonstrated to be potentially greater problems for no-till than conventional tillage, as a result of increased residue cover or different weed species, include black cutworm [*Agrostis ipsilon* (Hufnagel)], hopvine borer [*Hydraecia immanis* (Guenee)], southern corn billbug [*Sphenophorus callosus* (Oliver)], and common stalk borer [*Papaipema nebris* (Guenee)]. Black cutworm damage was found on 38.2% of the plants in no-till plots, and in 11.6% of the plants in conventional tillage plots, for a study in Ohio. A survey in Iowa in 1981 reported 17% damage in no-till, and only 4% damage in conventional tillage fields. Kuhlman and Steffey (1982) attributed the increased black cutworm damage to the undisturbed surface residue, and greater concentration of annual weeds in no-till. Greater hopvine borer and southern billbug damage has been associated with quackgrass and yellow nutsedge infestations, respectively, in no-till fields. Larger common stalk borer populations develop due to the greater early vegetation cover of a no-till field; larvae then move to young corn after the vegetation is killed by herbicides (Kuhlman and Steffey, 1982).

Weeds are a primary problem for most no-till fields. Increased levels of herbicide use may be required due to the residue cover on the soil surface. Higher weed densities or different weed species may develop into problems. Weed residue may be allelopathic to maize growth. As mentioned previously, a lower pH may reduce herbicide effectiveness. Erbach et al. (1980) obtained increasingly worse weed control over a four year period upon no-tillage plots, yet maintained excellent weed control on fall plowed conventionally tilled plots.

Methods and sources for fertilizer and pesticide application in no-till

Presumably, many of the problems associated with N loss and immobilization in a no-till system could be alleviated by using proper N sources and application methods. Touchton and Hargrove (1982) used three N sources and three application methods to examine the efficiency of different N fertilization techniques in no-till. The three N sources used were prilled urea, urea-ammonium nitrate solution (UAN), and prilled ammonium nitrate (AN). Application treatments included shallow incorporated and unincorporated band application of all N sources, plus a broadcast spray application of UAN. The study indicated that urea is generally a less efficient N source for no-till than either UAN or AN. Small differences were observed between incorporated and unincorporated band applications, with incorporated being slightly better. UAN as a broadcast spray was especially inefficient.

Mengel et al. (1982) used five combinations of N fertilizer application treatments to examine effects of placement and N source on fertilizer efficiency. Injecting ammonia (NH_4) or UAN 20 cm below the soil surface, resulted in consistently higher maize grain yields than applying UAN, ammonium nitrate (NH_4OH) or urea to the soil surface.

Injection of UAN produced from 690 to 1880 kg/ha more grain yield than surface application of UAN, in seven no-till environments. The difference was significant at the 5% level in six of the environments, and significant at the 1% level in four of the seven environments. Percentage N in the leaves and grain was also significantly higher with injected fertilizer treatments. For UAN, mean N in the ear leaf was 2.85% for injection, and 2.48% for surface application.

Hayes et al. (1983) discussed herbicide usage and weed control for no-till and conventional tillage systems. They suggested that perennial weeds have been the major factor limiting adoption of conservation tillage, particularly no-till. Hinkle (1983) suggested that resistance to herbicides can develop within weed species, through prolonged use of one family of herbicides. Also, selective loss of certain species or biotypes will tend to decrease competition for resistant types, both within and among species. Resistant biotypes would be a greater problem with no-till than with conventional tillage methods. Hayes et al. (1983) stated that proper utilization and management techniques with available pesticides can control weed problems in no-till fields.

Effect of no-till on other soil physical properties

Blevins et al. (1983) found no difference in bulk density between no-till and conventionally tilled soils after 10 years of continuous corn. They also stated that the increases in bulk density reported from other studies were not of sufficient magnitude to affect crop yields. Water transmission may be greater in no-till due to better pore continuity and increased earthworm activity.

Erbach et al. (1980) used a penetrometer cone index to estimate degree of soil compaction created by seven tillage systems. Prior to planting, the upper 6 inches in the plowed soil had less penetration resistance than in the no-till system. By August 24th, soil penetration resistance for the fall moldboard plow and no-till system was similar. Their results suggested that the greatest difference between no-till and conventional tillage for penetration resistance and other soil physical properties occurs in spring and early summer, and that differences begin to disappear by mid-summer. Blevins et al. (1983) stated that freezing and thawing probably relieve wheel track compaction caused by planting in a no-till system.

Effect of Reduced Tillage on Maize Growth and Grain Yield

The effect of conservation tillage and no-till systems on grain yield is highly dependent on the environment in which the system is used. Early reports of work in Virginia indicated higher grain yields were achieved by use of no-till, when planting into sod from the previous year (Shear and Moschler, 1969; Moschler et al., 1972). Jones et al. (1969) also reported increased grain yields from no-till in Virginia, when planting into corn stubble from the previous year. Griffith et al. (1973) used five locations in Indiana, and found that, in most cases, grain yields were reduced with the no-till system, relative to spring or fall plowing. In Missouri, Mason (1983) obtained lower grain yields on no-till plots at three of four locations used. A 10% reduction in grain yield was observed for no-till means across all environments, as compared to conventional tillage. No-till plots were planted into sod from the previous year.

Amemiya (1968) obtained higher grain yields on no-till (lister planted) plots planted into corn stubble in dry years, and comparable yields in other years, at a location in northwest Iowa. Amemiya (1968) designated five of the ten years between 1956 and 1966, the years in which the study was run, as having water stress. For those years with water stress, mean no-till yields were 47% higher than the corresponding conventional tillage yields. Mock and Erbach (1977), Erbach et al. (1980), and Hallauer (1982) all obtained lower grain yields on no-till plots than on conventionally tilled plots, with a continuous corn cropping system, on plots near Ames, Iowa. A 12% reduction in no-till grain yield compared to conventional tillage was observed for 5-year means from 1971 to 1975 by Erbach et al. (1980), and a 10% reduction using a 4-year means was observed by Hallauer (1982). Ketcheson (1977) reported a 25% grain yield reduction in no-till plots, relative to conventional tillage yields, with data collected from 1971 to 1975 in Ontario, Canada.

The above studies indicate that environmental differences have a major effect upon the grain yield performance of a no-till system versus a conventional tillage system. In some environments, insufficient water is the major limitation to grain yield, whereas for environments farther north or with poorly drained soils, the reduction in soil temperature is a more critical factor. Some of these studies will be examined individually, to report on effects of tillage on characters other than grain yield.

Main effects of reduced tillage on maize growth and grain yield

Jones et al. (1969), in Virginia, reported greater plant heights and stover yields on no-till, with stubble cover, than on conventional tillage without mulch. These factors, in addition to greater grain yields, were attributed to water conserving aspects of the mulch.

Griffith et al. (1973), in Indiana, reported that at eight weeks after planting, no-till (coulter planted) corn was the slowest growing on four of the five soil types used. The range in plant height reduction between no-till and conventional tillage maize was from 16 to 82 cm. This represented a 15% to 37% reduction in early plant height, respectively. Slower growth was ascribed to the colder, wetter soils associated with no-till. Stands were the lowest on chisel planted plots, and were average for no-till. Variations in stand were not great enough to explain the differences in grain yield observed.

Erbach et al. (1980) obtained the lowest final stand, out of seven tillage systems examined, on no-till, but the difference was not statistically significant. Rate of emergence was observed to be more erratic with conservation tillage systems than with fall moldboard plowing.

Genotype by tillage effects on maize growth and grain yield

The three studies discussed individually above used one maize hybrid each year to examine effects due to reduced tillage. The following studies used more than one genotype. Mean effects of tillage, and interactions of genotypes with tillage were discussed.

Mason (1983) used no-till and conventional tillage treatments following sod or fescue cover. Eighteen commercial corn hybrids were evaluated for two years, at three locations per year. Emergence was reduced by 10% in no-till, relative to conventional tillage. Barrenness percentage was relatively low, but was significantly greater for no-till in two of the six environments. Percentage root lodging was also relatively low; at one location in 1979, significantly more root lodging occurred in conventional tillage than in no-till. Stalk lodging was greater in conventional tillage, but not significantly so. Plant and ear height means across environments were somewhat greater on conventionally tilled plots, but not significantly so. Genotype x tillage interactions for grain yield were significant in only one out of six environments, and were not significant in a combined analysis. The rank correlation for yield between the two systems was 0.77, indicating that the ranking of the hybrids by yield was very similar in each tillage system. The hybrids ranked similarly for all traits in each tillage system.

Mock and Erbach (1977) evaluated eight genotypes in four tillage systems for two years. Four heterogeneous maize populations and four maize hybrids were used as genotypes. Final plant density and grain yield were lower in the conservation tillage systems than in the conventional tillage system in 1974. The planting date was 1 April in 1974. In 1975, the planting date was 30 April, uniform stands were obtained by thinning, and grain yield differences between tillage systems were not significant. For both years, the conventional tillage system had better and faster emergence, and greater early plant growth than the conservation tillage systems.

In the study by Mock and Erbach (1977), two of the populations evaluated were improved for cold tolerance using recurrent selection. The other two populations were the corresponding unimproved cycles (C0) of the cold tolerant populations. The only individual genotype data presented were the means across tillage systems. Some evidence for improved emergence and grain yield due to cold tolerance selection was observed. However, genotype-tillage means were not reported, and genotype x tillage interactions were not discussed.

Hallauer (1982) evaluated fourteen open pedigreed single-cross hybrids in four tillage systems. Two groups emerged from the four tillage systems; conventional tillage (FP) and spring disking (SD) seemed to produce one response, while strip-tillage (ST) and no-tillage (NT) were alike in producing a different reaction. Evaluated at a location near Ames, Iowa for four years, the FP and SD treatments produced significantly greater grain yields, lower grain moisture at harvest, and higher final stands than the ST and NT treatments. Grain yields were 11.4 quintals/ha higher (73.5 vs 62.1), grain moistures were 2 percentage points lower (29.5 vs 31.5), and final stands were 4,200 plants/ha higher (51,800 vs 47,600) when the FP and SD treatment mean was compared to the ST and NT treatment mean, respectively. However, hybrid x tillage interactions were not statistically significant.

Funnemark (1983) evaluated thirty maize hybrids classified as cold tolerant or noncold tolerant in two tillage systems at two locations in north central Iowa in 1980. A conventional tillage and conservation tillage system were used; however, the description of the tillage treatments states the conservation tillage system used fall disking and one pass in the spring with a field cultivator. One would suspect the majority of the residue would be covered by two passes with tillage implements. No large differences between tillage systems, or between cold tolerant and noncold tolerant hybrids were obtained for any of the traits examined.

In Nebraska, Brakke et al. (1983) evaluated 169 maize genotypes in two cropping systems, at two locations per cropping system in 1980. The cropping systems included an irrigated conventional tillage system, and an ecofallow system in which maize was planted into herbicide treated wheat stubble, with no irrigation. Locations and cropping systems were confounded, as only one of the locations was able to accommodate both cropping systems.

Brakke et al. (1983) reported highly significant differences between cropping systems for days to 50% silk, plant height, grain yield, and grain moisture at harvest. The ecofallow system had a significantly greater number of days to 50% silk, shorter plant height, and less grain yield than the irrigated conventional tillage system, as compared to a t-test (0.05). Harvest moisture was lower in the ecofallow system, but not significantly lower when compared by a t-test (0.05). The genotype x cropping system interaction was significant at the 0.01 level for all four traits when examined by an analysis of variance. Spearman rank correlations comparing yields in one system with the other were low, indicating the ranking of genotypes was different for each system.

From the above studies, it would appear that tillage systems certainly can affect plant growth and grain yield. Some differences in rankings between the systems can occur, as with the Brakke et al. (1983) study; however, genotype x tillage interactions usually are not significant. The greatest potential differences in soil physical properties relative to grain yield reduction is reduced soil temperatures.

In all of these studies except Brakke et al. (1983) study, only selected corn hybrids were used. And though Brakke et al. (1983) evaluated unselected as well as selected material, the top yielding lines which were reported for each tillage system were released commercial hybrids, also. No studies report on the evaluation of unselected genotypes in different tillage systems, to examine the effect of selection in a no-till system.

Relevant Related Studies

Selection for cold tolerance

During the 1970s and 1980s, several studies covering evaluation and selection for cold tolerant maize genotypes have been published. Cold tolerance in maize has been defined as the ability of genotypes to emerge and grow vigorously in cold soil and air temperatures. Mock and Eberhart (1972) determined that genetic variability for percentage emergence, rate of emergence, and seedling dry weight 45 days after planting existed within two Iowa Stiff Stalk Synthetic (BSSS) derived populations of maize, when S_1-lines *per se* were evaluated in a cold soil environment. Mock and Bakri (1976) reported that gains from recurrent selection using S_1-line *per se* evaluation had resulted in some progress, but that gains were primarily in improved percentage emergence. Mock and McNeill (1979) determined that variability for cold tolerance existed among 34 maize inbreds adapted to various latitudes of North America. Mock and Skrdla (1978), Miedema (1979), Eagles and Hardacre (1979a, 1979b), Hardacre and Eagles (1980), and Eagles and Brooking (1981) all have demonstrated that germplasm unadapted or exotic relative to corn belt germplasm may contain genes for improved cold tolerance not presently available in the corn belt germplasm gene pool. Alternatively, the studies indicated that it should be possible to develop cold tolerant germplasm for any geographical region of the world.

Selection for root characters

Barber (1971) examined the effects of tillage practice on corn roots. Eight different tillage residue management cropping practices for continuous maize production were used. Root lengths, weights, and distributions were examined by the use of soil cores. No-till treatments had shallower rooting systems, fewer roots, and larger root diameters than did conventional tillage treatments. When the evidence for an altered soil nutrient profile is considered in relation to the altered rooting pattern, one would suspect that a different type of rooting system might be favorable in no-till than in conventional tillage.

Breeding for root characteristics, as such, has been very limited to date. Recently, evaluation for genetic differences in 44 maize inbreds for pulling resistance, root dry weight, and root spread at different stages was reported (Jenison et al., 1981). Genetic differences for the traits were observed, indicating that different types of rooting systems can be developed through breeding procedures. Penny (1981) evaluated 33 of these inbreds and their testcrosses to inbreds W54A and Oh545, and determined that genetic differences for vertical root pull resistance were transmitted to testcross progenies, but at a lower magnitude than expressed in the inbreds.

Kevern and Hallauer (1983) evaluated unselected S_1-lines from the cycle 0 and cycle 8 of the maize breeding populations BSSS(R) and BSCB1(R); the advanced cycle populations were developed via a reciprocal recurrent selection program for grain yield improvement. The effects of the timing of root pull, components of variance, and correlations between root pull and agronomic traits were obtained. High heritability estimates ($H^2 = \sigma_g^2/\sigma_p^2$) indicated either pre- or postanthesis root pull would be effective in increasing root pull strength. No clear cut associations with agronomic traits were noted, aside from the desired, but small, negative correlation between root lodging and root pulling resistance. Eight cycles of reciprocal recurrent selection for grain yield produced a decrease in preflower root pull resistance in BSSS, and an increase in postflower root pull resistance for both BSSS and BSCB1.

If desirable root characters for no-till can be identified, selection for the desired characters should be possible with population improvement schemes.

MATERIALS AND METHODS

Plant Materials

Three sources of maize genotypes were used for the study. Each of the three sources was identified with a different experiment number. Experiment 1 used 100 S_1-lines from the maize population BS22(R)C1, Experiment 2 used 100 S_1-lines from the maize population BS13(SCT)C6, and Experiment 3 used 60 commercially available hybrids.

The BS22 population is currently being used in a reciprocal recurrent selection procedure by Dr. W. A. Russell of Iowa State University at Ames, Iowa. BS22 is a synthetic population constituted from the inbred lines A619, A632, CH9, C123, MS214, W153R, SD10, Va43, Mo17, B68, B55, SD15, M14, Pa884P, and (CMV3 x $B14^{\underline{x2}}$) sel. (Russell, 1975). The synthetic has germplasm contributed from the inbred B14 from A632, B68, and (CMV x $B14^{\underline{x2}}$) sel. In 1980, 210 S_1-lines from BS22(R)C1 were evaluated as half sib progenies, [tester = BS21(R)C1], in conjunction with the reciprocal recurrent selection procedure (Russell, 1980). Remnant seed from 110 of these S_1-lines was obtained, and increased, and 100 were used for this study. BS22 is an elite synthetic, adapted to the northern Iowa-southern Minnesota maturity zone.

The BS13(SCT) population was derived from BSSS(HT)C7 by Dr. J. J. Mock (Mock and Eberhart, 1972). S_1-line *per se* evaluation for cold tolerance was done for 6 cycles of recurrent selection. Evaluation of progress due to selection was reported by Mock and Bakri (1976).

The evaluation of S_1-lines from BS13(SCT)C6 for cold tolerance was done in 1980. Remnant seed from 110 of the S_1-lines evaluated was obtained, and increased, to provide lines for this study. BS13(SCT)C6 should be an excellent source of high yielding, cold tolerant germplasm, adapted to the central Iowa maturity zone.

The S_1-lines from each of the above populations were increased in Hawaii in the winter of 1980-1981, to provide seed for the 1981 growing season. Remnant seed was used to plant a row, and seed was increased by sib-mating within a row. Due to climatic difficulties, sufficient seed from only 40 of the S_1-lines from BS13(SCT)C6 was obtained from Hawaii. A full complement of 100 S_1-lines was obtained for BS22(R)C1. The same increase procedure was used at a location near Ames, Iowa, in the summer of 1981, to provide seed for the 1982 growing season. Sufficient seed for 100 S_1-lines from each population was obtained for the 1982 growing season.

Remnant seed for 60 of the commercial hybrids entered in the 1981 Iowa Corn Yield Test, Regions 1, 2, 3, and/or 5, was obtained from Ken Ziegler, Iowa State University, manager of the Iowa Corn Yield Test. The hybrid seed was stored in cold storage at all times other than during packaging. Sufficient seed supplies for both years of the study were available.

Field Techniques

Two tillage treatments were used for this study, a no-till and a conventional tillage system. A corn-on-corn rotation was practiced.

The no-till system used for this study had no cultivation prior to planting, for seedbed preparation, and no cultivation for weeds after planting. Plot rows were planted in corn stubble, about 20 cm off the previous year's row. Ridged were not formed; a flat field was maintained. Corn stalks were chopped the previous fall to provide a uniform residue cover for spring planting. The conventional tillage system used fall plowing, and spring disking and harrowing prior to planting. Cultivation for weeds was done as needed. Hereafter, in this study, the terms "conventional tillage" and "fall plow" will be used interchangeably.

Each tillage system was planted using a plot planter equipped with John Deere "Max-emerge" planter units. The seed furrow was opened with a ripple coulter, mounted ahead of each planter unit. Two row plots were used, with 76 cm row spacings. Each plot was 5.49 m long, of which 0.91 m was an alley between plot ranges. The experiment was planted in mid-to-late April at each environment.

All experiments were planted at locations near Ames, Iowa, and near Nashua, Iowa, in 1981 and 1982. The site near Ames was on the "Lippert" farm, managed by the Agronomy and Agricultural Engineering Research Center near Ames, Iowa. The site near Nashua, Iowa, was on the Northeast Research Center, located 1 mile south and 1.5 miles west of Nashua. Experiments 1 and 2 were also grown on the Northern Research Station near Kanawha, Iowa, in 1982. 1981 was the first year of no-till for the plots at Ames and Nashua, and 1982 was the first year of no-till for the plots near Kanawha, Iowa.

All plots were overplanted, and thinned to uniform stands when possible. In 1981, 35 seeds were planted per plot row, and a final stand of 24 plants/row was desired. However, poor emergence made this impossible in many cases. In 1982, 50 seeds per plot row were planted for Experiments 1 and 2, and 45 seeds per plot row were planted for Experiment 3. Germination and emergence were excellent, and uniform stands of near 24 plants/plot row were obtained after thinning. The desired plant density was 48 plants/2 row plot, or 57,400 plants/ha.

Volunteer corn was removed from both tillage treatments when necessary, by hand hoeing. Volunteer corn was a greater problem in no-till than in fall plow. Hand hoeing of weeds was necessary on no-till plots when chemical weed control was not sufficiently effective.

The soil environment for the emergence and early growth period was cool and dry at Ames in 1981, and cool and wet conditions were present at Nashua in 1981. In 1982, the soil conditions for emergence were warm and moist across the entire state, and excellent emergence was observed at all locations. However, during the last half of the month of May, cool and wet soil conditions developed, and persisted for 3-4 weeks. During this period, plant growth was slowed substantially. The experiments near Kanawha were submerged under water, and the soil was saturated with water for several days at a time. Cold stress was encountered for experiments planted in every environment. However, the timing of the cold stress was different in 1981 than in 1982.

Field Design

Two replications of a split-split plot design was used for each experiment at each environment in which it was grown. The main plots were the two tillage treatments used. Sets were subplots for this experiment, and were used as an incomplete blocking effect to remove microenvironment heterogeneity due to soil variability. Groups of 20 genotypes were randomly assigned to a set, and remained confounded to that set across all environments. Five sets of 20 genotypes each were used for Experiments 1 and 2, and three sets of 20 genotypes each were used for Experiment 3. Sets were randomly assigned to strips across the two tillage systems, such that a set of genotypes in no-till was adjacent to the same set in conventional tillage in each replication. The design was a subunit treatments in strips split plot design (Cochran and Cox, 1957). Sets were the subplots, and genotypes within sets were subsubplots. The genotype by tillage interactions were the effect of greatest interest for this study.

Traits Measured

Emergence counts were made for each subsubplot at approximately 2 weeks (EM1), 4 weeks (EM2), and 6 weeks (EM3) after planting. These counts were used to calculate an emergence index based upon the following formula:

$$[(EM1 * D1) + (EM2 - EM1) * D2 + (EM3 - EM2) * D3]/EM3,$$

where D1, D2, and D3 are the number of days after planting that EM1, EM2, and EM3, respectively, were measured ("*" means multiply). A percentage emergence (PEM) was calculated by dividing EM3 by the total number of seeds planted for each subsubplot, and multiplying by 100.

A visual rating for early vigor (EV) was made 7-8 weeks after planting. The rating attempted to quantify differences in green leaf area among subsubplots at an early vegetative stage, using a rapid visual rating. A 1 to 9 rating scale was used. A rating of 1 indicated the least amount of green leaf area present, and a 9 indicated the greatest amount of green leaf tissue was present. The ratings considered emergence, plant height, plant leaf area, and plant color. Early vigor ratings were made prior to thinning to uniform stands.

Early plant height (EPHT) was measured approximately 70 days after planting in 1981, and 60 days after planting in 1982. The distance from the ground level to the uppermost leaf collar was measured on 5 plants/row of each subsubplot, for a total of 10 plants/plot. The second plant in each row was measured, and every other plant following, up to five measurements per plot row. This sampling method was used to reduce inadvertent selection of the plants which were measured. A mean (EPHT), a within plot variance (EPHTV), and a within plot standard deviation (EPHTS) was calculated for each plot. A within plot coefficient of variability (EPHTCV) was calculated by the following formula:

$$EPHTCV = (100 \times EPHTS)/EPHT,$$

from Steel and Torrie (1960).

Another trait to quantify early vigor, using a fast and nondestructive method, was formed by multiplying the percentage of plants emerged (PEM) by the mean early plant height (EPHT). This product was divided by 10, to obtain a three digit number, and labeled biomass per plot (BMPP). BMPP, therefore, measured centimeters of early plant height obtained for each 10 seeds planted. The efficacy of obtaining the trait, and the correlation of BMPP with other vigor traits and with agronomic traits was examined.

Dates on which 25, 50, and 75% of the plants in a subsubplot displayed incipient silk extrusion (SK1, SK2, and SK3, respectively) and pollen shed (PS1, PS2, and PS3, respectively) were obtained at four of the five environments for Experiments 1 and 2, and at three of the four environments for Experiment 3. Dates of pollen shedding and silking were expressed as days after planting. A plant was determined to be shedding pollen when dehiscent anthers were present at least half way down the central tassel branch. A measure of the silk extrusion interval (SKI) was obtained by substracting the 25% silk date from the 75% silk date (SKI = SK3 - SK1). Likewise, a pollen shedding interval was obtained by subtracting the 25% pollen shed date from the 75% pollen shed date (PI = PS3 - PS1). A pollen-shed-to-silking interval (PSKI) was calculated for each subsubplot by subtracting the date of 50% pollen shed from the date of 50% silking (PSKI = SK2 - PS2).

At plant maturity, plant and ear heights (PHT and EHT, respectively) were measured as distances in cm from the soil surface to the collar of the flag leaf, and the node of primary ear attachment, respectively. Ten plants were measured per plot; the within plot variance, standard deviations, and coefficients of variability for plant height (PHTV, PHTS, and PHTCV, respectively), and ear height (EHTV, EHTS, and EHTCV, respectively), were calculated as for early plant height. Also at this time, final stand counts (FST) were made, to establish the number of plants in each plot that grain yields and other harvest traits would be based on.

Visual ratings for stay green (SG) were made near the end of the grain filling period, when approximately 50% of the leaf tissue was discolored across the entire experiment. The rating was based on a 1 to 9 scale, where 1 indicated complete discoloration of leaf and stem tissue, and 9 indicated little or no discoloration of the stalk and leaf tissue. Each subsubplot was given a rating.

Prior to harvest, counts were made for the number of plants stalk lodged, root lodged, and the number of dropped ears per plot. Plants with stalks broken below the ear node were considered stalk lodged, and plants leaning more than 30^{o} from the vertical were considered root lodged. These counts were put on a percentage basis through division by FST, to compute percentage stalk lodging (PSL), percentage root lodging (PRL), and percentage dropped ears (PDE).

Final harvest was done with a self-propelled plot combine. Grain yield per plot was the total amount of shelled grain harvested per subsubplot by the combine. No gleaning was done for dropped ears. Percentage grain moisture at harvest (M) was determined by measuring a sample of the grain from each subsubplot with a portable moisture meter. Yields were adjusted to 15.5% moisture for all plots, and converted from pounds per plot to g/m^2 (GPMS) through multiplication by a factor of 54.2. Weight per plant (WPP) was obtained by dividing grain weight per plot in grams, adjusted to 15.5% moisture, by final stand (FST). As stands were somewhat variable, the error regression of GPMS on FST was examined for significance, on an environment-tillage basis. If the regression was significant, adjustment of GPMS to a common stand was done, through the method outlined in LeClerg et al. (1962), to calculate grain yield in g/m^2 adjusted for stand (GPMSA). A degree of freedom was removed from the subsubplot error for each environment-tillage system in which the adjustment was made.

Statistical Procedures

The statistical analysis of this study was approached in two ways. First, the performance of genotypes across two tillage systems was analyzed, to determine the significance of genotype by tillage interactions in a statistical sense. Next, the ramifications of selection in one tillage system versus the other were examined. The analysis of variance procedure, therefore, was done across tillage systems, as well as within each tillage system separately.

A mixed model was assumed for the analysis of variance across tillage systems and environments. Tillage was the only fixed effect for Experiments 1 and 2. For Experiment 3, sets and genotypes were also considered fixed effects. The model used for the combined analysis across tillage systems and environments was:

$$Y_{ijklm} = m + E_i + (R/E)_{ij} + T_k + (ET)_{ik} + \alpha_{ijk} + S_l + (ES)_{il} + (TS)_{kl} + (ETS)_{ikl} + \beta_{ijkl} + (G/S)_{lm} + [(EG)/S]_{ilm} + [(TG)/S]_{klm} + [(ETG)/S]_{iklm} + \psi_{ijklm} ,$$

where:

Y_{ijklm} = observed value of the ijklmth subsubplot,

m = experiment mean,

E_i = effect of the ith environment; i = 1, 2, 3, 4, 5 for Experiments 1 and 2 and i = 1, 2, 3, 4 for Experiment 3,

$(R/E)_{ij}$ = *effect of the jth replication within the ith* environment; j = 1, 2,

T_k = effect of the kth tillage system; k = 1, 2,

$(ET)_{ik}$ = effect of the interaction of the ith environment with the kth tillage system,

α_{ijk} = main plot error (error a),

S_l = effect of the lth set, l = 1, 2, 3, 4, 5 for Experiments 1 and 2, and l = 1, 2, 3 for Experiment 3,

$(ES)_{il}$ = effect of the interaction of the ith environment with the lth set,

$(TS)_{kl}$ = effect of the interaction of the kth tillage system with the lth set,

$(ETS)_{ikl}$ = effect of the interaction of the ith environment and the kth tillage system with the lth set,

β_{ijkl} = subplot error (error b),

$(G/S)_{lm}$ = effect of the m^{th} genotype within the l^{th} set, $m = 1, \ldots 20$,

$[(EG)/S]_{ilm}$ = effect of the interaction of the i^{th} environment with the m^{th} genotype within the l^{th} set,

$[(TG)/S]_{klm}$ = effect of the interaction of the k^{th} tillage system with the m^{th} genotype within the l^{th} set,

$[(ETG)/S]_{iklm}$ = effect of the interaction of the i^{th} environment and the k^{th} tillage system with the m^{th} genotype within the l^{th} set, and

ψ_{ijklm} = residual error (error c).

Components of the combined analysis of variance across tillage systems for Experiment 1 and 2 are indicated in Table 2. Expected mean squares were calculated according to the method of Steel and Torrie (1960). Table 3 indicates the components of the combined analysis across tillage systems for Experiment 3, with genotypes and sets as fixed, rather than random, effects. Variance components for sources involving genotypes, and their associated standard errors, were calculated for Experiments 1 and 2 as outlined in Hallauer and Miranda (1981). If a variance component estimation resulted in a negative number, it was reported as such, as suggested by Dudley and Moll (1969). However, if the estimate was used to calculate subsequent variance components, or to calculate heritability estimates, a negative estimate was considered to be zero.

Heritability (H^2) estimates over tillage systems, on an entry mean basis, were calculated for Experiments 1 and 2, as adapted from

Table 2. Components of the combined analysis of variance across environments and tillage systems, for Experiments 1 and 2

Source	df	E(MS)[a]
Environments (E)	e-1	
Replications (R)/E	e(r-1)	
Tillage (T)	t-1	$\sigma_a^2 + rgs\sigma_{TE}^2 + rgse \frac{\Sigma T^2}{(t-1)}$
T x E	(t-1)(e-1)	$\sigma_a^2 + rgs\sigma_{TE}^2$
Error a	e(r-1)(t-1)	$\sigma_{a'}^2 = \sigma_b^2 + gs\sigma_{TR/E}^2$
Sets (S)	s-1	$\sigma_b^2 + rgt\sigma_{SE}^2 + rgte\sigma_S^2$
S x E	(s-1)(e-1)	$\sigma_b^2 + rgt\sigma_{SE}^2$
S x T	(s-1)(t-1)	$\sigma_b^2 + rg\sigma_{STE}^2 + rge\sigma_{ST}^2$
S x T x E	(s-1)(t-1)(e-1)	$\sigma_b^2 + rg\sigma_{STE}^2$
Error b (pooled error)	e(r-1)(s-1) + e(r-1)(s-1)(t-1)	$\sigma_{b'}^2 = \sigma_c^2 + g\sigma_{STR/E}^2 + gt\sigma_{SR/E}^2$

Genotypes (G)/S	s(g-1)	$\sigma_c^2 + rt\sigma_{GE/S}^2 + rte\sigma_{G/S}^2$
G x E/S	s(g-1)(e-1)	$\sigma_c^2 + rt\sigma_{GE/S}^2$
G x T/S	s(g-1)(t-1)	$\sigma_c^2 + r\sigma_{GTE/S}^2 + re\sigma_{GT/S}^2$
G x T x E/S	s(g-1)(t-1)(e-1)	$\sigma_c^2 + r\sigma_{GTE/S}^2$
Error c (residual)	rs(g-1)(e-1) + rs(g-1)(e-1)(t-1)	σ_c^2
Total	ertsg-1	

[a]Tillage was fixed, and environments, sets, and genotypes were random effects.

Table 3. Components of the combined analysis of variance across environments and tillage systems, for Experiment 3

Source	df	E(MS)[a]
Environments (E)	e-1	
Replications (R)/E	e(r-1)	
Tillage (T)	t-1	$\sigma_a^2 + rgs\sigma_{TE}^2 + rgse \frac{\Sigma T^2}{(t-1)}$
T x E	(t-1)(e-1)	$\sigma_a^2 + rgs\sigma_{TE}^2$
Error a	e(r-1)(t-1)	$\sigma_a^2, = \sigma_b^2 + gs\sigma_{TR/E}^2$
Sets (S)	s-1	$\sigma_b^2 + rgt\sigma_{SE}^2 + rgte \frac{\Sigma S^2}{(s-1)}$
S x E	(s-1)(e-1)	$\sigma_b^2 + rgt\sigma_{SE}^2$
S x T	(s-1)(t-1)	$\sigma_b^2 + rg\sigma_{STE}^2 + rge \frac{\Sigma (ST)^2}{(s-1)(t-1)}$
S x T x E	(s-1)(t-1)(e-1)	$\sigma_b^2 + rg\sigma_{STE}^2$
Error b (pooled error)	e(r-1)(s-1) + e (r-1)(s-1)(t-1)	$\sigma_b^2, = \sigma_c^2 + rgt\sigma_{SR/E}^2 + rg\sigma_{STR/E}^2$

Genotypes (G)/S	s(g-1)	$\sigma_c^2 + rt\sigma_{GE/S}^2 + rte \frac{\overset{\Sigma}{s(\Sigma G^2)}}{s(g-1)}$
G x E/S	s(g-1)(e-1)	$\sigma_c^2 + rt\sigma_{GE/S}^2$
G x T/S	s(g-1)(t-1)	$\sigma_c^2 + r\sigma_{GTE/S}^2 + re \frac{\overset{\Sigma}{s[\Sigma (GT)^2]}}{s(g-1)(t-1)}$
G x T x E/S	s(g-1)(t-1)(e-1)	$\sigma_c^2 + r\sigma_{GTE/S}^2$
Error c (residual)	rs(g-1)(e-1) + rs(g-1)(e-1)(t-1)	σ_c^2
Total	ertsg-1	

[a]Environments were random, and tillage, sets, and genotypes were fixed effects.

Hallauer and Miranda (1981):

$$H^2 = \frac{\sigma_G^2}{\frac{\sigma^2}{tre} + \frac{\sigma_{GE}^2}{e} + \sigma_G^2} ,$$

where t = 2, r = 2, and e = 5. Standard errors for heritabilities were likewise calculated according to Hallauer and Miranda (1981). Variance components were not calculated for Experiment 3, due to the fixed genotypes used, but repeatability estimates were obtained using the same method as for calculation of heritabilities, with e = 4.

The model for the analysis of variance within each tillage system was:

$$Y_{ijkl} = m + E_i + (R/E)_{ij} + S_k + \alpha_{ijk} + (G/S)_{kl} + [(EG)/S]_{ikl} + \beta_{ijkl}$$

where:

Y_{ijkl} = observed value of the ijklth subplot,

m = experiment mean,

E_i = effect of the ith environment,

$(R/E)_{ij}$ = effect of the jth rep in the ith environment,

S_k = effect of the kth set,

$(ES)_{ik}$ = effect of the interaction of the ith environment with the kth set,

α_{ijk} = error a,

$(G/S)_{kl}$ = effect of the lth genotype in the kth set,

$[(EG)/S]_{ikl}$ = effect of the interaction of the ith environment and the lth genotype within the kth set, and

β_{ijkl} = error b (residual error).

This model was used within each tillage system. For Experiments 1 and 2, all effects were considered random. Sets and genotypes effects were considered fixed for Experiment 3. Components of the combined analysis of variance within each tillage system for Experiments 1 and 2 are indicated in Table 4, and Table 5 lists the components for Experiment 3. The same protocol for reporting and using variance component estimates was followed as for the combined analysis of variance across tillage systems. Heritability (H^2) estimates within tillage systems on an entry mean basis were calculated for Experiments 1 and 2 by the following formula:

$$H^2 = \frac{\sigma_G^2}{\frac{\sigma^2}{re} + \frac{\sigma_{GE}^2}{e} + \sigma_G^2} ,$$

where r = 2, and e = 5. Repeatability estimates for Experiment 3 were calculated in a similar fashion, with e = 4. In order to compare the estimates for genotypic variance and heritability between the two tillage systems, an analysis of variance was obtained by pooling sums of squares and degrees of freedom across the two tillage systems. The mean squares from the pooled analysis were then used to calculate standard errors for the pooled σ_G^2 and pooled H^2; these standard errors were used to compare the estimates from the two tillage systems. A difference of more than two standard deviations was considered to be a significant difference.

Simple product moment correlations were obtained, using means

Table 4. Components of the combined analysis of variance across environments, within a tillage system, for Experiments 1 and 2

Source	df	E(MS)[a]
Environments (E)	(e-1)	
Replications (R)/E	e(r-1)	
Sets (S)	(s-1)	$\sigma_a^2 + rg\sigma_{SE}^2 + rge\sigma_S^2$
S x E	(s-1)(e-1)	$\sigma_a^2 + rg\sigma_{SE}^2$
Error a	e(r-1)(s-1)	$\sigma_a^2, = \sigma_b^2 + g\sigma_{SR/E}^2$
Genotypes (G)/S	s(g-1)	$\sigma_b^2 + r\sigma_{GE/S}^2 + re\sigma_{G/S}^2$
G x E/S	s(g-1)(e-1)	$\sigma_b^2 + r\sigma_{GE/S}^2$
Error b (residual)	se(r-1)(g-1)	σ_b^2
Total	ersg-1	

[a]Environments, sets, and genotypes were random effects.

Table 5. Components of the combined analysis of variance across environments, within a tillage system, for Experiment 3

Source	df	E(MS)[a]
Environments (E)	e-1	
Replications (R)/E	e(r-1)	
Sets (S)	s-1	$\sigma_a^2 + rg\sigma_{SE}^2 + rge\,\frac{\Sigma S^2}{(s-1)}$
S x E	(s-1)(e-1)	$\sigma_a^2 + rg\sigma_{SE}^2$
Error a	e(r-1)(s-1)	$\sigma_a^2, = \sigma_b^2 + g\sigma_{SR/E}^2$
Genotypes (G)/S	s(g-1)	$\sigma_b^2 + r\sigma_{GE/S}^2 + re\,\frac{\underset{S}{\Sigma}(\Sigma G^2)}{S(g-1)}$
G x E/S	s(g-1)(e-1)	$\sigma_b^2 + r\sigma_{GE/S}^2$
Error b (residual)	se(r-1)(g-1)	σ_b^2
Total	ersg-1	

[a]Sets and genotypes were fixed, and environments were random effects.

across environments for each genotype in each tillage system. Genotypic correlations were calculated using the following formula from Mode and Robinson (1959):

$$r_{gij} = \frac{\sigma^2_{G_iG_j}}{(\sigma^2_{G_i} \cdot \sigma^2_{G_j})^{1/2}} ,$$

where $\sigma^2_{G_iG_j}$ = genotypic covariance between traits i and j, and where $\sigma^2_{G_i}$ and $\sigma^2_{G_j}$ = genotypic variance of traits i and j, respectively.

Spearman rank correlation coefficients were calculated to compare the rankings of genotypes in one tillage system with the rankings in the other tillage system, for the traits measured.

Two types of index selection for multiple traits were used. First, a Smith-Hazel (SHI) index selection system was used. The details for construction of the index are presented in Becker (1967). The Smith-Hazel index for this study used equal economic weights for all selected traits, and nonstandardized values. Selection was done for Experiments 1 and 2. The traits in the index were GPMS, M, PSL, PRL, and BMPP.

Also, a performance index (PFI), using heritabilities (or repeatabilities) as b-values, and nonstandardized values, was calculated for Experiments 1, 2, and 3. The variables used for the performance index were quintals/ha adjusted for stand (QPHA, = GPMSA/10), M, PSL, PRL, and PDE.

RESULTS

Experiment 1: S_1-lines from BS22(R)C1

Results will be presented in three sections: (1) analyses of variance for the traits measured, (2) correlations among the traits, and (3) selection of lines from each tillage system.

Analysis of variance

For the analysis of variance section, each of the traits examined will be discussed. Means, variance components, and heritabilities were estimated from the overall analysis, and from each tillage system separately.

The analysis of variance section will be discussed in five subsections: (1) early vigor traits, (2) pollen shedding and silking traits, (3) mature plant traits, (4) harvest traits, and (5) within plot variability traits. The subplot analysis will not be discussed, since sets (S) were only used as an incomplete blocking effect.

In this dissertation, the terms "analysis of variance" and "anova" will be used interchangeably.

Early vigor traits   Percentage emergence (PEM), a visual rating for early vigor (EV), an emergence rate index (EMI), early plant height (EPHT), and a biomass per plot rating (BMPP) were the early vigor traits measured. PEM, EV, and EPHT had significant variation for environments (E) in the combined anova over environments and tillage systems (Table 6). Variation due to tillage (T) was significant for EV and EMI, and the tillage by environment interaction (T x E) was

Table 6. The combined analysis of variance, over environments and tillage systems, for early vigor traits in Experiment 1

Source of variation	df	Trait				
		PEM	EV	EMI	EPHT	BMPP
		%	1-9	days	cm	cm
Environments (E)	4	130776.26**	347.75**	107.69	9814.31**	96387
Replications (R)/E	5	1087.00	26.68	452.36	446.71	46669
Tillage (T)	1	27614.77	697.60**	4776.94**	12733.83	1123102
T x E	4	11131.10**	61.92	791.80	2895.53**	158815*
Error a (T x R/E)	5	819.65	24.43	206.13	236.42	16572
Sets (S)	4	340.04	2.53	71.10*	371.39	28723
S x E	16	401.77	6.94	36.50	196.36*	16260*
S x T	4	616.96	12.30	28.45	197.17	19451
S x T x E	16	615.03	4.94	41.78	49.29	7033
Error b (Pooled error)	40	596.24	5.38	35.48	79.42	8497
Genotypes (G)/S	95	536.60**	3.53**	21.54	32.90**	6234**
G x E/S	379	192.47**	1.51**	14.72	14.70**	2055**
G x T/S	95	110.00	1.06	9.78	9.92	1248
G x T x E/S	379	112.10*	0.90	12.50	8.02	1258
Error c (Pooled error)	948	94.09	0.93	23.62	10.01	1112

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

significant for the other three early vigor traits. The greatest difference in environments for PEM was between years. For 1981, the mean PEM across locations was 57%; in 1982, the mean PEM was 87% (Table 7). Mean EV was lower (4.2 vs 5.7), the emergence rate (EMI) mean was slower (19.8 vs 19.1 days), and the mean BMPP rating was lower (147 vs 158 cm) in 1981 than in 1982, respectively. The EPHT mean was larger in 1981 than 1982, however (25.9 vs 18.2 cm, respectively). For means across environments, no-till reduced PEM 7.4%, EV was reduced 1.2 units, EMI was 3.1 days slower, EPHT was 5 cm shorter, and BMPP was 48 cm less, relative to fall plow. The environment that had the largest tillage induced differences for early vigor was Ames in 1981. The PEM was 49.7% in no-till vs 75.9% in fall plow, EV was 2.7 in no-till and 5.0 in fall plow, EMI was 22.4 days in no-till and 16.3 days in fall plow, EPHT was 20.5 cm in no-till and 27.0 cm in fall plow, and BMPP was 104 cm in no-till, and 204 cm in fall plow. Nashua in 1981 was the next most severe environment; EPHT was 21.4 cm in no-till, and 34.9 cm in fall plow, a reduction of 39% in no-till relative to fall plow. PEM was near 50% for both tillage systems.

The genotypes within sets (G/S) and genotype by environment within sets (G x E/S) sources were significant for PEM, EV, EPHT, and BMPP (Table 6). No sources involving genotypes were significant for EMI. The genotype by tillage by environment within set (G x T x E/S) interaction was significant for PEM, but no other early vigor trait had a significant interaction involving genotypes and tillage. The ratio of σ^2 to σ_G^2 ranged from 5.4 for BMPP (1112 vs 208, respectively) to

Table 7. Environment, tillage, and environment-tillage means for early vigor traits in Experiment 1

Type of mean		PEM	EV	EMI	EPHT	BMPP
		Trait				
		%	1-9	days	cm	cm
Experiment mean, overall		74.6	5.1	19.4	21.3	154
Tillage means:	No-till (NT)	70.9	4.5	20.9	18.8	130
	Fall plow (FP)	78.3	5.7	17.8	23.8	178
Year means:	1981	57.0	4.2	19.8	25.9	147
	1982	87.1	5.7	19.1	18.2	158
Location means:	Nashua	69.2	5.4	19.1	23.5	154
	Ames	76.8	4.7	19.6	19.4	145
	Kanawha	81.2	5.3	19.4	20.8	171
Environment means:	Nashua 1981 (1)	49.1	4.4	19.2	28.1	141
	Ames 1981 (2)	62.8	3.9	19.4	23.7	154
	Kanawha 1982 (3)	81.2	5.3	19.4	20.8	171
	Nashua 1982 (4)	89.3	6.3	18.6	18.8	168
	Ames 1982 (5)	90.7	5.6	19.2	15.0	137
Environment-tillage means:	1-NT	48.1	3.8	21.8	21.4	104
	1-FP	50.1	5.1	16.6	34.9	178
	2-NT	49.7	2.7	22.4	20.5	104
	2-FP	75.9	5.0	16.3	27.0	204
	3-NT	79.1	5.2	19.9	21.2	171
	3-FP	83.3	5.3	18.8	20.3	171
	4-NT	88.5	5.8	18.8	17.4	154
	4-FP	90.1	6.7	18.4	20.3	183
	5-NT	89.2	4.9	20.0	13.4	120
	5-FP	92.3	6.2	18.4	16.6	153

11.0 for EPHT (10.01 vs 0.91) (Table 8). The ratios of σ^2_{GE} to σ^2_G were in the 1.0 to 1.5 range. Heritability (H^2) estimates ranged from 55% for EPHT to 67% for BMPP.

In no-till, all traits except EMI had significant E, G/S, and G x E/S sources of variation (Table 9a). In fall plow, PEM and BMPP had significant variation due to environments, all traits except EMI had significant genotypic variation, and PEM and BMPP had significant genotype by environment interations (Table 9b). No sources from anovas for either tillage system were significant for the EMI trait. Variance component estimates were similar for the two systems for PEM, as were the heritability estimates (Table 10). EV had relatively more genotypic variation expressed in no-till than in fall plow, and the heritability (H^2) was 53% in no-till, and 41% in fall plow. EMI had no genotypic variation expressed. The σ^2 estimate for EPHT was 2.4 times larger in fall plow than in no-till; the H^2 estimate was 61% in no-till and 37% in fall plow. The estimates for σ^2_G and σ^2_{GE} were somewhat larger in fall plow for BMPP, and the estimate for σ^2 was 2.2 times greater in fall plow. The H^2 estimate for BMPP was 60% in no-till, and 53% in fall plow.

Pollen shedding and silking traits The traits included for pollen shedding and silking were 50% pollen shedding date (PS2), 50% silking date (SK2), pollen shedding interval (PI), silking interval (SKI), and pollen-shedding-to-silking interval (PSKI). In the combined anova over tillage systems and environments (Table 11), environmental variation was significant for PS2, SK2, PI, and PSKI, the tillage

Table 8. Variance component estimates and heritability estimates from the combined analysis of variance, over environments and tillage systems, for (a) early vigor traits, and (b) pollen shedding and silking traits in Experiment 1

Trait	σ^2_G	σ^2_{GE}	σ^2_{GT}	σ^2_{GTE}	σ^2	H^2
(a) Early vigor traits						
PEM, %	17.21 ± 3.92	24.60 ± 1.46	-0.21 ± 1.78	9.01 ± 4.60	94.09	0.64 ± 0.15
EV, 1-9	0.10 ± 0.03	0.15 ± 0.01	0.01 ± 0.02	0.00 ± 0.04	0.93	0.57 ± 0.17
EMI, days	-0.10 ± 0.16	-2.23 ± 0.15	-1.38 ± 0.17	-5.56 ± 0.71	23.62	---[a]
EPHT, cm	0.91 ± 0.24	1.17 ± 0.12	-0.01 ± 0.15	-1.00 ± 0.37	10.01	0.55 ± 0.15
BMPP, cm	208 ± 45	236 ± 16	-2 ± 20	73 ± 52	1112	0.67 ± 0.14
(b) Pollen shedding and silking traits						
PS2, days	0.71 ± 0.18	0.80 ± 0.12	0.04 ± 0.06	0.19 ± 0.13	2.40	0.72 ± 0.18
SK2, days	0.78 ± 0.21	1.04 ± 0.16	0.08 ± 0.08	0.00 ± 0.16	3.20	0.68 ± 0.18
PI, days	0.02 ± 0.02	0.05 ± 0.05	-0.01 ± 0.05	0.34 ± 0.12	1.84	0.16 ± 0.16
SKI, days	-0.01 ± 0.03	0.15 ± 0.07	0.03 ± 0.07	0.35 ± 0.15	2.46	---[a]
PSKI, days	0.13 ± 0.06	0.37 ± 0.08	0.00 ± 0.04	-0.11 ± 0.09	2.06	0.42 ± 0.20

[a]No heritability estimate was calculated for this trait, since significant genotype variation was not present.

Table 9. The combined analysis of variance for early vigor traits, with (a) the no-till system, and (b) the fall plow system, in Experiment 1

Source of variation	df	Trait				
		PEM	EV	EMI	EPHT	BMPP
		%	1-9	days	cm	cm
(a) Combined anova for no-till						
Environments (E)	4	83977.76**	295.97**	703.66	2289.08**	185707*
Replications (R)/E	5	1831.72	21.70	558.59	143.32	23301
Sets (S)	4	885.28	9.31	87.63	166.60*	23986
S x E	16	751.63	14.74*	57.08	73.46	10236
Error a (S x R/E)	20	854.84	6.19	49.40	41.46	8750
Genotypes (G)/S	95	352.51**	2.48**	19.10	18.08**	2910**
G x E/S	379	162.96**	1.17**	18.60	7.04*	1164**
Error b (residual)	474	91.12	0.76	35.07	5.89	698
(b) Combined anova for fall plow						
Environments (E)	4	57929.60**	113.70	195.83	10420.75	69495**
Replications (R)/E	5	75.33	29.54	99.81	539.82	39939
Sets (S)	4	71.71	5.52	11.91	401.96*	24189*
S x E	16	265.16	5.56	21.21	172.19	13057
Error a (S x R/E)	20	337.89	4.57	22.04	107.74	8244
Genotypes (G)/S	95	321.09**	2.10**	12.22	24.73**	4572**
G x E/S	379	141.61**	1.24	8.62	15.68	2149**
Error b (residual)	474	97.06	1.11	12.16	14.13	1526

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 10. Variance component estimates and heritability estimates, from the combined analysis of variance, within each tillage system for Experiment 1. Estimates for (a) early vigor traits, and (b) pollen shedding and silking traits, are listed

	No-till estimates				Fall plow estimates			
Trait	σ_G^2	σ_{GE}^2	σ^2	H^2	σ_G^2	σ_{GE}^2	σ^2	H^2
(a) Early vigor traits								
PEM, %	18.96	35.92	91.12	0.54	17.95	22.28	97.06	0.56
EV, 1-9	0.13	0.21	0.76	0.53	0.09	0.07	1.11	0.41
EMI, days	-0.80	-8.24	35.07	--[a]	0.01	-1.77	12.16	--
EPHT, cm	1.10	0.58	5.89	0.61	0.91	0.78	14.13	0.37
BMPP, cm	175	233	698	0.60	242	312	1526	0.53
(b) Pollen shedding and silking traits								
PS2, days	0.83	1.16	2.39	0.64	0.63	0.63	2.41	0.63
SK2, days	0.93	1.51	3.26	0.60	0.71	0.59	3.13	0.62
PI, days	0.08	0.09	2.21	0.25	-0.05	0.34	1.48	--
SKI, days	-0.03	0.47	2.70	--	0.03	0.18	2.22	0.10
PSKI, days	0.14	0.22	2.02	0.36	0.22	-0.13	1.86	0.54

[a]Estimate not calculated, due to the lack of significant genotypic variation.

source was significant for PS2 and SK2, and the T x E interaction was significant for SKI. For this experiment, the no-till means for PS2 and SK2 were 2.5 days later than the fall plow means (Table 12). In 1981 at Nashua, the PI and SKI means were larger in no-till than in fall plow, but for other environments the differences were minor.

All pollen shedding and silking traits except SKI had significant genotypic variation, and the G x E/S interaction was significant for all the traits except PI (Table 11). The PS2 trait had a significant G x T/S interaction, and PI and SKI had a significant G x T x E/S interaction. PS2 and SK2 had similar variance component estimates (Table 8); the H^2 estimate for PS2 was 72% and the H^2 estimate for SK2 was 68%. PI and SKI had little or no genotypic variance expressed, and the σ^2_{GTE} variance components were the largest in magnitude. The σ^2_{GE} variance component was relatively large for PSKI, and the H^2 estimate was 42%.

Variation due to environments was significant for all five pollen shedding and silking traits in no-till (Table 13a), but only for PI and PSKI in fall plow (Table 13b). In no-till, all traits except SKI had significant genotypic variation, and PS2, SK2, SKI, and PSKI had a significant G x E/S interaction. In fall plow, all traits except PI had significant genotypic variation, and PS2, SK2, and PI had a significant G x E/S interaction.

Variance component estimates and heritability estimates were similar for PS2 and SK2, and differed little from no-till to fall plow (Table 10). H^2 estimates were in the 60-65% range. PI and SKI had

Table 11. The combined analysis of variance, over environments and tillage systems, for pollen shedding and silking traits in Experiment 1

		Trait				
Source of variation	df	PS2	SK2	PI	SKI	PSKI
		days	days	days	days	days
Environments (E)	3	1192.08*	1386.84*	283.03**	235.99	1059.57**
Replications (R)/E	4	174.74	160.31	6.77	47.79	7.06
Tillage (T)	1	2559.17**	2503.76**	12.46	77.63	0.30
T x E	3	329.72	372.98	15.21	97.66**	17.32
Error a (T x R/E)	4	67.31	71.64	5.59	2.76	2.64
Sets (S)	4	191.73**	176.58	0.43	3.33	5.82
S x E	12	47.65	79.81*	7.68*	4.06	5.63
S x T	4	29.01	35.73	6.72	5.10	3.29
S x T x E	12	5.91	9.35	1.80	3.11	2.71
Error b (Pooled error)	32	25.11	31.84	3.32	4.44	3.05
Genotypes (G)/S	95	19.76**	22.99**	2.44*	2.76	6.07**
G x E/S	284	5.59**	7.37**	2.02	3.05*	3.52**
G x T/S	95	3.22*	3.98	2.43	3.49	2.03
G x T x E/S	284	2.78	3.20	2.51**	3.16**	1.85
Error c (Pooled error)	758	2.40	3.20	1.84	2.46	2.06

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 12. Environment, tillage, and environment-tillage means for pollen shedding and silking traits in Experiment 1

Type of mean		PS2	SK2	PI	SKI	PSKI
		Trait				
		days	days	days	days	days
Experiment mean, overall		85.3	87.9	4.3	4.5	2.6
Tillage means:	No-till (NT)	86.6	89.1	4.4	4.8	2.6
	Fall plow (FP)	84.1	86.6	4.2	4.3	2.6
Year means:	1981	86.0	88.1	4.7	4.9	2.0
	1982	84.6	87.7	4.0	4.1	3.1
Location means:	Nashua	86.5	86.7	5.6	5.7	0.2
	Ames	86.0	89.5	3.9	4.2	3.5
	Kanawha	82.8	85.9	4.0	4.1	3.1
Environment means:	Nashua 1981 (1)	86.5	86.7	5.6	5.7	0.2
	Ames 1981 (2)	85.6	89.5	3.8	4.2	3.9
	Kanawha 1982 (3)	82.8	85.9	4.0	4.0	3.1
	Nashua 1982 (4)	--[a]	--	--	--	--
	Ames 1982 (5)	86.4	89.5	3.9	4.2	3.1
Environment-tillage means:	1-NT	88.5	88.9	6.0	6.6	0.4
	1-FP	84.4	84.4	5.2	4.7	0.0
	2-NT	87.1	90.6	3.8	4.0	3.6
	2-FP	84.1	88.3	3.8	4.3	4.2
	3-NT	82.7	85.9	4.0	4.1	3.2
	3-FP	82.8	86.0	4.0	4.0	3.1
	4-NT	--	--	--	--	--
	4-FP	--	--	--	--	--
	5-NT	88.0	91.1	3.9	4.3	3.1
	5-FP	84.8	87.9	4.0	4.1	3.1

[a]Data for these traits were not collected at all environments.

Table 13. The combined analysis of variance for pollen shedding and silking traits, with (a) the no-till system, and (b) the fall plow system, in Experiment 1

Source of variation	df	Trait				
		PS2	SK2	PI	SKI	PSKI
		days	days	days	days	days
(a) Combined anova for no-till						
Environments (E)	3	1374.61*	1108.99**	214.52**	314.62*	423.19**
Replications (R)/E	4	84.98	48.62	9.54	32.16	6.08
Sets (S)	4	85.31*	80.05	2.95	5.13	2.32
S x E	12	32.67	55.44	4.01	3.56	4.21
Error a (S x R/E)	16	21.89	31.16	3.20	3.44	2.27
Genotypes (G)/S	95	13.01**	15.61**	3.22**	3.35	3.83**
G x E/S	284	4.70**	6.27**	2.38	3.63**	2.46*
Error b (residual)	379	2.39	3.26	2.21	2.70	2.02
(b) Combined anova for fall plow						
Environments (E)	3	147.19	650.83	83.71**	19.02	653.71**
Replications (R)/E	4	157.09	183.33	2.82	18.41	3.64
Sets (S)	4	135.43*	132.26*	4.21	3.30	6.79
S x E	12	20.89	33.72	5.47	3.61	4.13
Error a (S x R/E)	16	28.57	32.76	2.96	5.43	3.59
Genotypes (G)/S	95	9.97**	11.37**	1.64	2.90*	4.28**
G x E/S	284	3.66*	4.30**	2.15**	2.57	1.86
Error b (residual)	379	2.40	3.13	1.48	2.22	2.11

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

little genotypic variation expressed. For PSKI, the σ^2 estimate was 14.4 times larger than the σ^2_G estimate in no-till, and 8.5 times larger in no-till. The H^2 estimate for PSKI was 36% in fall plow, and 54% in fall plow.

Mature plant traits   Traits measured after anthesis and prior to harvest included plant height (PHT), ear height (EHT), and stay green (SG). For PHT and EHT, the E, T, G/S, and G x E/S sources were significant at the 1% level in the combined anova over environments and tillage systems (Table 14). The PHT mean was reduced 6 cm and the EHT mean was reduced 4 cm in no-till, relative to fall plow (Table 15). The variance component estimates across tillage systems for PHT were all approximately twice as large as the estimates for EHT (Table 16). The H^2 estimate for PHT was 81%, and for EHT was 82%.

The E, G/S, and G x E/S sources of variation were significant at the 1% level for PHT and EHT in each of the combined anovas within a tillage system (Table 17). The σ^2_G estimate for PHT was 3.25 standard deviations higher in no-till than fall plow, and the σ^2 estimate for EHT was twice as large in fall plow than in no-till (Table 18). The H^2 estimates for PHT and EHT were 81% and 82%, respectively, in no-till, and 70% and 70%, respectively, in fall plow.

For stay green (SG), the T x E, G/S, G x E/S, and G x T/S sources of variation were significant in the combined anova over environments and tillage systems (Table 14). The overall effect of tillage was minor; the no-till mean for SG was 4.4, and the fall plow mean was 4.2 (Table 15). Within an environment, the effect of tillage was variable.

Table 14. The combined analysis of variance, over environments and tillage systems, for mature plant traits in Experiment 1

Source of variation	df	Trait		
		PHT	EHT	SG
		cm	cm	1-9
Environments (E)	4	39321**	16127**	98.42
Replications (R)/E	5	208	204	28.77
Tillage (T)	1	13854**	9740**	23.16
T x E	4	821	1083	45.24*
Error a (T x R/E)	5	594	252	4.48
Sets (S)	4	8591**	5280**	54.01*
S x E	16	1136**	443**	15.24**
S x T	4	259	176	4.23
S x T x E	16	179	91	3.14
Error b (Pooled error)	40	201	94	2.82
Genotypes (G)/S	95	1578**	868**	18.20**
G x E/S	379	302**	159**	3.37**
G x T/S	95	103	38	2.24**
G x T x E/S	379	87	49	1.68
Error c (Pooled error)	948	82	44	1.58

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 15. Environment, tillage, and environment-tillage means for mature plant traits in Experiment 1

Type of mean		Trait	
	PHT	EHT	SG
	cm	cm	1-9
Experiment mean, overall	148	56	4.3
Tillage means: No-till (NT)	145	54	4.4
Fall plow (FP)	151	58	4.2
Year means: 1981	150	58	4.4
1982	146	54	4.3
Location means: Nashua	154	59	4.4
Ames	138	51	4.0
Kanawha	155	58	4.8
Environment means: Nashua 1981 (1)	157	59	4.3
Ames 1981 (2)	144	58	4.6
Kanawha 1982 (3)	155	58	4.8
Nashua 1982 (4)	152	59	4.5
Ames 1982 (5)	132	44	3.5
Environment-tillage means: 1-NT	156	58	4.4
1-FP	158	61	4.1
2-NT	140	53	4.3
2-FP	149	62	4.8
3-NT	153	58	4.6
3-FP	156	59	5.0
4-NT	148	56	4.9
4-FP	156	62	4.1
5-NT	130	43	4.0
5-FP	135	46	3.0

Table 16. Variance component estimates and heritability estimates from the combined analysis of variance, over environments and tillage systems, for (a) mature plant traits, and (b) harvest traits, in Experiment 1

Trait	σ^2_G	σ^2_{GE}	σ^2_{GT}	σ^2_{GTE}	σ^2	H^2
(a) Mature plant traits						
PHT, cm	64 ± 11	55 ± 6	2 ± 2	3 ± 4	82	0.81 ± 0.14
EHT, cm	36 ± 6	29 ± 3	-1 ± 1	3 ± 2	44	0.82 ± 0.14
SG, 1-9	0.74 ± 0.06	0.45 ± 0.06	0.06 ± 0.03	0.05 ± 0.07	1.58	0.81 ± 0.14
(b) Harvest traits						
GPMS, g/m^2	1949 ± 407	2592 ± 127	-18 ± 120	473 ± 314	6638	0.70 ± 0.15
GPMSA, g/m^2	1733 ± 356	2114 ± 108	-15 ± 111	525 ± 290	5996	0.71 ± 0.15
WPP, g	72 ± 16	97 ± 5	-2 ± 10	-2 ± 13	312	0.67 ± 0.15
M, %	0.72 ± 0.15	0.88 ± 0.05	-0.05 ± 0.05	0.12 ± 0.14	3.07	0.69 ± 0.15
PSL, %	21.26 ± 4.53	31.06 ± 1.47	2.50 ± 2.04	16.24 ± 4.20	73.66	0.68 ± 0.15
PRL, %	0.22 ± 0.12	0.72 ± 0.09	0.26 ± 0.17	0.31 ± 0.36	8.03	0.29 ± 0.15
PDE, %	0.01 ± 0.01	0.05 ± 0.01	0.00 ± 0.01	0.00 ± 0.03	0.63	---[a]
FST, #/plot	3.00 ± 0.96	12.60 ± 0.51	-0.22 ± 0.35	2.19 ± 0.95	18.84	0.46 ± 0.15

[a]No heritability estimate was calculated for this trait, since significant genotypic variation was not present.

Table 17. The combined analysis of variance for mature plant traits, within (a) the no-till system, and (b) the fall plow system, in Experiment 1

Source of variation	df	Trait PHT	EHT	SG
		cm	cm	1-9
(a) Combined anova for no-till				
Environments (E)	4	22064**	7361**	24.04
Replications (R)/E	5	272	123	14.90
Sets (S)	4	3961**	2401**	23.14
S x E	16	590**	194	11.69**
Error a (S x R/E)	20	157	102	2.21
Genotypes (G)/S	95	1038**	527**	13.38**
G x E/S	379	196**	95**	2.55**
Error b (residual)	474	58	28	1.22
(b) Combined anova for fall plow				
Environments (E)	4	18077**	9849**	119.61*
Replications (R)/E	5	531	330	18.35
Sets (S)	4	4888	3055**	35.10**
S x E	16	725	340**	6.69
Error a (S x R/E)	20	1884	85	3.42
Genotypes (G)/S	95	643**	379**	7.07**
G x E/S	379	192**	113**	2.49**
Error b (residual)	474	106	60	1.94

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 18. Variance component estimates and heritability estimates, from the combined analysis of variance within each tillage system for Experiment 1. Estimates for (a) mature plant traits, and (b) harvest traits, are listed

Trait	No-till estimates				Fall plow estimates			
	σ_G^2	σ_{GE}^2	σ^2	H^2	σ_G^2	σ_{GE}^2	σ^2	H^2
(a) Mature plant traits								
PHT, cm	84	69	58	0.81	45	43	106	0.70
EHT, cm	43	34	28	0.82	27	27	60	0.70
SG, 1-9	1.08	0.67	1.22	0.81	0.46	0.28	1.94	0.65
(b) Harvest traits								
GPMS, g/m^2	2416	2725	5788	0.68	1464	2932	7488	0.52
GPMSA, g/m^2	2019	2346	4742	0.68	1431	2407	7249	0.54
WPP, g	89	81	313	0.65	52	113	312	0.49
M, %	0.95	1.31	3.03	0.63	0.45	0.58	3.11	0.51
PSL, %	31.67	61.18	42.79	0.66	13.40	17.19	104.50	0.49
PRL, %	0.44	0.74	4.98	0.41	0.26	1.01	11.08	--[a]
PDE, %	0.01	0.04	0.61	--	0.01	0.07	0.64	--
FST, #/plot	3.98	12.47	25.72	0.44	1.79	14.93	11.95	0.30

[a]Estimates not calculated, due to the lack of significant genotypic variation.

S.E. for σ^2_G	$\frac{NT\sigma^2_G - FP\sigma^2_G}{\text{S.E. for } \sigma^2_G}$	S.E. for σ^2_{GE}	S.E. for H^2
12	3.25	8	0.15
14	1.14	4	0.14
0.15	4.13	0.10	0.15
464	2.05	495	0.15
409	1.44	435	0.15
18	2.06	21	0.15
0.18	2.78	0.21	0.15
5.53	3.30	6.00	0.17
0.20	--	0.44	--
0.01	--	0.03	--
1.13	1.94	1.78	0.15

In three environments, the SG mean was higher in no-till, and in the other two environments, the SG mean was higher in fall plow. The ratio of σ^2 to σ_G^2 was about 2.0, and the H^2 estimate over tillage systems was 81% (Table 16).

SG had significant G/S and G x E/S sources in the combined anova for no-till (Table 17a), and significant E, G/S, and G x E/S sources within the fall plow combined anova (Table 17b). The estimate for σ_G^2 was 2.3 times larger in no-till than fall plow, and the σ^2 estimate was smaller in no-till than fall plow (Table 18). The H^2 estimate for SG was 81% in no-till, and 65% in fall plow.

Harvest traits Traits measured at or near harvest included grain yield, grain moisture, stalk and root lodging, dropped ears, and final stand. These harvest traits were of primary importance, from an economic view point.

Grain yield was examined by three methods. Grain yield expressed as grams per square meter (GPMS) was calculated, grain yield adjusted for stand variability and expressed as grams per square meter (GPMSA) was calculated, and grain weight per plant in grams (WPP) was calculated.

All three yield traits had significant environment and tillage sources of variation, and both GPMS and GPMSA had a significant T x E interactions in the combined anova over tillage systems and environments (Table 19). Means for GPMS and GPMSA were equal on Table 20, since adjustment for stand was done within an environment-tillage block. The overall GPMS mean was 355 g/m^2, and the overall WPP mean was 73 g/plant. Environment means for GPMS ranged from 294 to 441 g/m^2, and the range

Table 19. The combined analysis of variance, over environments and tillage systems, for harvest traits in Experiment 1

Source of variation	df	Trait GPMS	GPMSA	WPP
		g/m^2	g/m^2	g
Environments (E)	4	1367412**	1367301**	120681**
Replications (R)/E	5	44850	38966	2329
Tillage (T)	1	1707130*	1760944*	26692*
T x E	4	216411**	216314*	7338
Error a (T x R/E)	5	18973	21746	1690
Sets (S)	4	174746**	153581**	6225**
S x E	16	25349	18358	618
S x T	4	17443	10705	62
S x T x E	16	6787	6448	453
Error b (Pooled error)	40	18840	14246	747
Genotypes (G)/S	95	55976**	49104**	2144**
G x E/S	379	17004**	14451**	701**
G x T/S	95	7403	6891	289
G x T x E/S	379	7584	7045*	309
Error c (Pooled error)	948	6638	5996[a]	312

[a]GPMSA had 945 df for Error c, as one degree of freedom was used to make the correction for stand variability for 3 environment-tillage blocks.

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Trait				
M	PSL	PRL	PDE	FST
%	%	%	%	#/plot
1029.52	230199.90**	436.38	8.58**	11255.04**
442.18	1723.06	93.55	0.12	140.71
98.94	1957.60	119.82	0.48	2712.89
59.49	1399.01	92.33	0.72	2548.69**
36.25	934.40	28.24	0.27	63.12
38.89	159.10	22.37	0.84	53.55
16.49*	223.71	19.69	1.27	108.69
9.41	178.96	37.23*	0.35	85.85
5.93	261.73	17.81	0.66	55.46
7.99	196.91	13.46	0.70	66.26
21.08**	623.06**	15.38*	1.01	129.18**
6.60**	197.88**	10.92**	0.81**	69.24**
2.78	131.68	11.24**	0.61	21.00
3.31	106.14**	8.64	0.63	23.22**
3.07	73.66	8.03	0.63	18.84

Table 20. Environment, tillage, and environment-tillage means for harvest traits in Experiment 1

Type of mean		GPMS	GPMSA	WPP	M	PSL	PRL	PDE	FST
		Trait							
		g/m^2	g/m^2	g	%	%	%	%	#/plot
Experiment mean, overall		355	355	73	21.5	16.2	1.0	0.2	42.3
Tillage means:	No-till (NT)	326	326	69	21.8	15.2	0.8	0.2	41.1
	Fall plow (FP)	384	384	77	21.3	17.2	1.3	0.2	43.4
Year means:	1981	364	364	86	21.8	3.6	0.9	0.3	36.7
	1982	349	349	64	21.3	24.6	1.1	0.1	46.0
Location means:	Nashua	347	347	76	20.0	31.4	2.1	0.1	40.0
	Ames	320	320	65	22.4	3.5	0.4	0.3	42.8
	Kanawha	441	441	81	23.0	11.2	0.1	0.2	45.8
Environment means:	Nashua 1981 (1)	382	382	95	20.4	4.1	1.7	0.2	34.5
	Ames 1981 (2)	346	346	77	23.3	3.0	0.2	0.4	39.0
	Kanawha 1982 (3)	441	441	81	23.0	11.2	0.1	0.2	45.8
	Nashua 1982 (4)	312	312	58	19.5	58.7	2.5	0.0	45.5
	Ames 1982 (5)	294	294	51	21.5	3.9	0.6	0.2	46.5
Environment-tillage means:	1-NT	357	357	87	21.2	3.0	0.7	0.1	34.8
	1-FP	406	406	103	19.6	5.2	2.7	0.2	34.2
	2-NT	288	288	78	23.4	2.6	0.1	0.4	33.3
	2-FP	404	404	77	23.2	3.4	0.2	0.5	44.6
	3-NT	435	435	80	23.0	11.8	0.1	0.2	46.6
	3-FP	447	447	82	22.9	10.6	0.1	0.2	46.0
	4-NT	304	304	56	19.3	54.5	2.1	0.0	45.4
	4-FP	321	321	59	19.8	62.9	2.9	0.0	45.6
	5-NT	245	245	44	22.0	4.0	0.8	0.2	46.4
	5-FP	343	343	62	21.1	3.8	0.4	0.1	46.7

for WPP was 51 to 95 g/plant. The no-till mean for GPMS was 15% lower than the fall plow mean (326 vs 384 g/m^2, respectively), and the no-till WPP mean was 10% lower than the fall plow mean (69 vs 77 g/plant, respectively). The largest tillage induced reductions in GPMS were noted at Ames. In both 1981 and 1982 at Ames, there was a 29% reduction in the GPMS mean in no-till, relative to fall plow. For WPP, the largest differences between the two tillage systems were at Nashua in 1981 and Ames in 1982. The no-till mean at Nashua in 1981 was 16 g lower than the fall plow mean, for a 16% reduction, and at Ames in 1982, the no-till WPP mean was 18 g lower, which was a 29% reduction.

The G/S and G x E/S sources of variation were significant for GPMS, GPMSA, and WPP in the combined anova over tillage systems, and for GPMSA the G x T x E/S interaction was significant (Table 19). The relative levels of σ^2_G, σ^2_{GE}, and σ^2 were similar for each of the three grain yield traits, and the H^2 estimates over tillage systems were 70%, 71%, and 67% for GPMS, GPMSA, and WPP, respectively (Table 16).

The E, G/S, and G x E/S sources were significant for all three grain yield traits, for the combined anovas within tillage systems (Table 21). The estimates for σ^2_G were larger in no-till than fall plow, for all three grain yield traits (Table 18). For GPMS and WPP, the difference between the σ^2_G estimates for two tillage systems was more than two standard deviations. The σ^2 estimates for GPMS and GPMSA were also lower in no-till than fall plow. H^2 estimates for GPMS, GPMSA, and WPP were 68%, 68%, and 65% in no-till, and 52%, 54%, and 49% in fall plow, respectively.

Table 21. The combined analysis of variance for harvest traits, with (a) the no-till system, and (b) the fall plow system, in Experiment 1

Source of variation	df	Trait GPMS	GPMSA	WPP
		g/m^2	g/m^2	g
(a) Combined anova for no-till				
Environments (E)	4	1056191**	1055981**	65689**
Replications (R)/E	5	27865	24716	2995
Sets (S)	4	84418**	63905**	2975**
S x E	16	21941	15454	702
Error a (S x R/E)	20	18805	13288	745
Genotypes (G)/S	95	35392**	29619**	1363**
G x E/S	379	11237**	9433**	475**
Error b (residual)	474	5788	4742[a]	313
(b) Combined anova for fall plow				
Environments (E)	4	527633**	527633**	62611**
Replications (R)/E	5	35959	36050	1033
Sets (S)	4	107772**	100381**	3346*
S x E	16	1096	9352	371
Error a (S x R/E)	20	18850	15202	775
Genotypes (G)/S	95	27988**	26376**	1053**
G x E/S	379	13352**	12063**	537**
Error b (residual)	474	7488	7249[b]	312

[a]Degrees of freedom associated with this error term are 471.

[b]Degrees of freedom associated with this error term are 473.

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Trait				
M	PSL	PRL	PDE	FST
%	%	%	%	#/plot
533.93*	99516.11**	126.52	2.93	8379.53**
65.90	220.34	46.64	1.57	189.80
28.34**	297.71	56.68*	0.83	112.21
12.84	351.28**	14.50	0.99	130.91
6.24	81.57	13.87	0.61	112.42
15.12**	481.83**	10.89**	0.76	90.45**
5.64**	165.15**	6.46**	0.68	50.65**
3.03	42.79	4.98	0.61	25.72
555.08	132082.80**	402.18*	6.37**	5424.00**
202.62	2437.17	75.15	0.38	14.03
19.96	40.35	2.91	0.35	27.19
9.58	134.16	23.04	0.93	33.24
9.53	312.72	12.81	0.89	20.60
8.74**	272.90**	15.73	0.86	59.73**
4.27**	138.87**	13.10*	0.77*	41.81**
3.11	104.50	11.08	0.64	11.95

For grain moisture (M), the E, T, and T x E sources were not significant in the combined anova over environments and tillage systems (Table 19). In four of five environments, the M mean in no-till was slightly larger than the M mean in fall plow (Table 20). The overall no-till mean for M was 21.8%, and the fall plow mean was 21.3%. In the subsubplot analysis, the G/S and G x E/S sources were significant (Table 19). The σ^2 estimate was about 4.3 times larger than the σ_G^2 estimate, and σ_{GE}^2 was about 1.2 times larger than σ_G^2 (Table 16). The H^2 estimate over tillage systems for M was 69%.

Within tillage systems, the E, G/S, and G x E/S sources were significant for M in the combined anova for no-till, and G/S and G x E/S were significant in the combined anova for fall plow (Table 21). The σ_G^2 estimate in no-till was 2.78 standard deviations larger in no-till than in fall plow (Table 18). The H^2 estimate for no-till was 63%, and for fall plow the H^2 estimate was 51%.

Percentage stalk lodging (PSL) had significant environmental variation in the combined anova over environments and tillage systems, but T and T x E sources were not significant. For PRL, the E, T, and T x E sources were not significant in the combined anova over tillage systems (Table 19). The PSL mean tended to be lower in no-till than fall plow. The mean no-till PSL was 15.2%, and the fall plow mean was 17.2% (Table 20). PRL had a relatively low experiment mean (1.0%). The no-till mean for PRL was 0.8%, and the fall plow PRL was 1.3%.

Both PSL and PRL had significant G/S and G x E/S sources of variation for the combined anova over tillage systems (Table 19).

Also, PSL had a significant G x T x E/S interaction. Relatively little genotypic variability for PRL was expressed. The ratio of σ^2 to σ^2_G was about 3.5 for PSL, and 36.5 for PRL, and the ratio of σ^2_{GE} to σ^2_G was 1.5 for PSL and 3.3 for PRL (Table 16). The H^2 estimate over tillage systems for PSL was 68%, and for PRL was 29%.

In the combined analysis within each tillage system, PSL had significant sources for E, G/S, and G x E/S in both tillage systems (Table 21). For PRL in no-till, the G/S and G x E/S sources were significant, and in fall plow, the E and G x E/S sources were significant. Significant genotypic variation was not observed in fall plow. The σ^2_G estimate for PSL was 3.3 standard deviations larger in no-till than in fall plow (Table 18). For PRL, the σ^2_G estimate was 0.44 for no-till, and 0.26 for fall plow. An H^2 estimate for PRL in fall plow was not calculated, due to the lack of significant genotypic variation. The H^2 estimates for PRL in no-till was 41%, and the H^2 estimates for PSL were 66% and 49% in no-till and fall plow, respectively.

Data for percentage dropped ears (PDE) is listed on Tables 16, 18, 19, 20, and 21. The trait was of minor significance for this study, as the means were very low (Table 20), and no genotypic variation was expressed in the anova over tillage systems (Table 19), or in either of the anovas within a tillage system (Table 20). Therefore, the trait will not be discussed further.

The environments source and the T x E interaction were significant at the 1% level for final stand (FST) in the combined anova over tillage systems (Table 19). The greatest difference in environments was between years. The 1981 mean for FST was 36.7 plants/plot, and the mean for 1982 was 46.0 plants/plot (Table 20). The only environment in which a large difference in FST was noted between tillage systems was Ames, 1981, where the no-till mean was 33.3 plants/plot, and the fall plow mean was 44.6 plants/plot. The G/S, G x E/S, and G x T/S sources of variation were significant in the subsubplot analysis for the combined anova over environments and tillage systems (Table 19). The estimate for σ^2 was 6.3 times larger than the σ^2_G estimate, and the H^2 estimate over tillage systems was 46% (Table 16).

For the anovas within tillage systems for FST, the E, G/S, and G x E/S sources were significant at the 1% level in both tillage systems (Table 21). The σ^2_G estimate was 1.94 standard deviations larger in no-till, and the σ^2 estimate was 2.2 times larger in no-till than in fall plow (Table 18). The H^2 estimate for FST was 44% in no-till, and 30% in fall plow. This study used thinning to attempt to achieve uniform stands. The significant sources of variation observed for FST indicate that genotypic differences for final stand were still present after thinning.

Within plot variability traits   Plant heights, ear heights, and early plant heights were measured on ten plants in each subsubplot. The within plot variance for these measurements were calculated (PHTV, EHTV, and EPHTV, respectively). The standard errors associated with these variances (PHTS, EHTS, and EPHTS, respectively) were examined in an analysis of variance, and the coefficients of variability (PHTCV, EHTCV, and EPHTCV, respectively) were also examined in an anova to investigate the effect of tillage on within plot variability.

For PHTS, no significant effect due to T or T x E was noted, but for PHTCV, the T source was significant (Table 22). The PHTCV mean was 10.8% in no-till, and 10.2% in fall plow (Table 23). The PHTCV mean was slightly higher for no-till in every environment. EHTS and EHTCV had significant T x E interactions in the combined anova over tillage systems (Table 22). In 1981, EHTS and EHTCV tended to be greater in no-till than fall plow, but the reverse was true in 1982 at Nashua and Ames (Table 23). EPHTS had a significant T x E interaction in the combined anova over tillage systems, but EPHTCV did not have a significant T effect or T x E interaction (Table 22). The EHTS mean was lower in no-till than fall plow in 1981, but similar for both tillage systems in 1982 (Table 23). No consistent tillage effect on EPHTCV was noted.

Summary for the analysis of variance section

Twenty-seven traits were examined in a combined analysis of variance for Experiment 1 (Tables 6, 11, 14, 19, and 22). Of the twenty-seven traits, only three (PS2, PHT, and SG) exhibited a genotype by tillage interaction mean square which was significantly greater than its respective error. Five traits (PEM, PI, SKI, GPMSA, and PSL) had significant genotype by tillage by environment interaction mean squares.

For ten of the twenty-seven traits, significant differences due to tillage were noted. Eleven traits exhibited significant tillage by environment interactions. The only traits which had significant effects for both tillage and tillage by environments were GPMS and GPMSA. Large

Table 22. The combined analysis of variance, over environments and tillage systems, for within plot variability traits in Experiment 1

Source of variation	df	PHTS	EHTS	EPHTS	PHTCV	EHTCV	EPHTCV
		Trait					
		cm	cm	cm	%	%	%
Environments (E)	4	801.71**	105.08	1063.99**	384.83**	3035.10**	4899.25
Replications (R)/E	5	55.92	22.74	38.74	32.36	228.24	1236.41
Tillage (T)	1	37.16	86.12	504.19	155.87*	362.50	137.69
T x E	4	106.15	61.29**	116.76*	53.97	330.09*	319.47
Error a (T x R/E)	5	35.79	3.66	14.07	14.15	30.85	301.60
Sets (S)	4	26.90	24.87*	14.56*	36.96	584.62**	21.57
S x E	16	18.86	17.09	5.97	12.65	82.80	94.08
S x T	4	18.61	12.97	5.69	17.13	127.83	18.64
S x T x E	16	24.04	8.76	2.97	13.35	39.45	59.54
Error b (Pooled error)	40	28.24	10.12	5.20	19.03	67.25	92.91
Genotypes (G)/S	95	57.60**	32.39**	2.85	31.69**	194.18**	76.54**
G x E/S	379	25.13**	13.12**	2.26*	12.35**	64.46**	44.32
G x T/S	95	19.73	9.30	1.96	10.34	35.52	46.62
G x T x E/S	379	16.81	10.37	2.25	8.38	38.64	40.03
Error c (Pooled error)	948	18.42	10.40	1.96	8.90	39.09	53.64

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 23. Environment, tillage, and environment tillage means for within plot variability traits in Experiment 1

Type of mean			PHTS	EHTS	EPHTS	PHTCV	EHTCV	EPHTCV
			Trait					
			cm	cm	cm	%	%	%
Experiment mean, overall			15.4	11.8	4.4	10.5	22.0	20.5
Tillage means:	No-till (NT)		15.5	11.6	3.9	10.8	22.4	20.8
	Fall plow (FP)		15.2	12.0	4.9	10.2	21.6	20.3
Year means:	1981		14.5	11.8	6.1	9.7	20.9	23.7
	1982		16.0	11.8	3.2	11.1	22.8	18.4
Location means:	Nashua		15.6	11.7	4.9	11.2	22.3	18.0
	Ames		14.4	11.5	4.2	10.2	20.4	20.7
	Kanawha		17.1	12.5	3.6	10.5	23.8	22.4
Environment means:	Nashua 1981 (1)		15.7	12.1	6.8	10.1	21.1	24.8
	Ames 1981 (2)		13.2	11.5	5.3	9.2	20.7	22.6
	Kanawha 1982 (3)		17.1	12.5	3.6	11.1	22.1	17.7
	Nashua 1982 (4)		15.5	11.3	3.0	10.3	19.6	16.3
	Ames 1982 (5)		15.5	11.5	3.1	11.8	26.7	21.3
Environment-tillage means:		1-NT	15.9	12.3	5.5	10.3	22.0	25.8
		1-FP	15.4	12.0	8.1	9.9	20.3	23.8
		2-NT	14.1	11.5	4.5	10.1	22.4	22.4
		2-FP	12.2	11.4	6.1	8.3	18.9	22.8
		3-NT	17.1	12.5	3.5	11.2	22.2	18.7
		3-FP	17.2	12.6	3.8	11.1	22.0	19.1
		4-NT	15.2	10.6	3.0	10.4	19.4	17.4
		4-FP	15.7	12.1	3.0	10.2	19.7	15.1
		5-NT	15.3	10.9	2.0	11.8	26.2	21.7
		5-FP	15.7	12.0	3.4	11.7	27.2	20.9

tillage by environment interactions masked the tillage effect for several of the traits. The experiment was designed to examine genotype by tillage interactions; as such, the test for tillage required a relatively large F statistic in order to realize a significant tillage effect.

Twenty-three of the traits exhibited significant genotypic variation in the combined analysis of variance over tillage systems and environments. Only EMI, SKI, PDE, and EHT did not have significant genotypic variation. Of these four traits, the genotype by environment interaction was significant for SKI, PDE, and EHT.

Correlations among traits

For the correlations section, traits were split into three groups: (1) agronomic traits, including GPMS, GPMSA, WPP, M, PSL, PRL, PDE, FST, SG, PHT, EHT, and the performance index (PFI) described in the materials and methods section, (2) early vigor traits, including PEM, EV, EMI, EPHT, and BMPP, and (3) pollen shedding and silking traits, including PS2, SK2, PI, SKI, and PSKI.

Correlations within each tillage system The correlations among the agronomic traits will be discussed first. Phenotypic correlations among the three grain yield traits in no-till were high, especially between GPMS and GPMSA (0.93), and between GPMSA and WPP (0.93) (Table 24a). The correlation coefficient between GPMS and WPP was 0.79. WPP had a negative but nonsignificant correlation with FST, and GPMS had a positive correlation of 0.43 with FST. GPMSA was relatively uncorrelated with FST in no-till (0.09). Genetic correlations among the

Table 24. Correlations among agronomic traits in Experiment 1, for (a) no-till, and (b) fall plow. Coefficients above the diagonal are simple product moment correlations using entry-tillage means, and below the diagonal are genetic correlation coefficients

	Trait				
Trait	GPMS	GPMSA	WPP	M	PSL
	g/m^2	g/m^2	g	%	%
(a) Correlations in no-till					
GPMS		0.93**	0.79**	0.34**	-0.11
GPMSA	0.96**		0.93**	0.39**	-0.12
WPP	0.87**	0.98**		0.38**	-0.14
M	0.48**	0.54**	0.47**		0.02
PSL	-0.06	-0.08	-0.16	0.02	
PRL	-0.06	-0.17	-0.23*	-0.12	0.10
PDE	---[a]	---	---	---	---
FST	0.45**	0.15	0.06	0.02	0.13
SG	0.62**	0.67**	0.69**	0.53**	-0.01
PHT	0.63**	0.62**	0.57**	0.37**	0.38**
EHT	0.52**	0.52**	0.45**	0.41**	0.62**

[a]Genetic correlations were not calculated, since significant genotypic variation was not present for one or both of the traits.

*,**Significant at the 5% and 1% level of probability, respectively.

Trait						
PRL	PDE	FST	SG	PHT	EHT	PFI
%	%	#/plot	1-9	cm	cm	
0.02	0.06	0.43**	0.55**	0.57**	0.51**	0.62**
-0.04	0.05	0.09	0.59**	0.59**	0.53**	0.66**
-0.05	0.05	-0.16	0.58**	0.56**	0.48**	0.64**
-0.12	0.04	-0.05	0.51**	0.32**	0.33**	0.11
0.00	0.01	0.03	-0.06	0.30**	0.46**	-0.81**
	-0.18	0.14	-0.14	0.08	0.18	-0.08
---		0.06	0.14	0.04	0.06	0.03
0.41**	---		0.03	0.13	0.13	0.03
-0.23*	---	0.01		0.52**	0.48**	0.35**
0.04	---	0.29**	0.56**		0.82**	0.10
0.14	---	0.23*	0.47**	0.80**		-0.06

Table 24. (Continued)

Trait	Trait				
	GPMS	GPMSA	WPP	M	PSL
	g/m^2	g/m^2	g	%	%
(b) Correlations in fall plow					
GPMS		0.99**	0.81**	0.36**	-0.22*
GPMSA	0.98**		0.86**	0.37**	-0.21*
WPP	0.87**	0.96**		0.38**	-0.10
M	0.57**	0.56**	0.57**		-0.01
PSL	-0.33**	-0.25*	-0.10	0.02	
PRL	---	---	---	---	---
PDE	---	---	---	---	---
FST	0.32**	0.26**	-0.18	-0.10	-0.35**
SG	0.51**	0.57**	0.57**	0.59**	-0.26**
PHT	0.53**	0.52**	0.55**	0.34**	0.04
EHT	0.46**	0.49**	0.55**	0.24*	0.38**

Trait						
PRL	PDE	FST	SG	PHT	EHT	PFI
%	%	#/plot	1-9	cm	cm	
0.25*	0.04	0.33**	0.50**	0.58**	0.52**	0.79**
0.25*	0.05	0.23*	0.51**	0.58**	0.53**	0.79**
0.19	0.12	-0.26**	0.50**	0.57**	0.55**	0.62**
0.04	0.10	-0.04	0.54**	0.32**	0.29**	0.16
-0.20	0.08	-0.16	-0.18	0.05	0.23*	-0.75**
	-0.08	0.09	0.08	0.21*	0.10	0.25*
---		-0.08	-0.02	-0.04	0.00	-0.03
---	---		0.01	0.07	0.00	0.27**
---	---	-0.09		0.50**	0.42**	0.41**
---	---	0.08	0.46**		0.79**	0.34**
---	---	-0.07	0.35**	0.73**		0.20*

grain yield traits were similar to the phenotypic correlations. In fall plow, the simple correlation between GPMS and GPMSA was larger than in no-till, as stands were more uniform in fall plow, and less adjustment for stand was required (Table 24b). The correlation coefficient between GPMS and FST was 0.33, between GPMSA and FST was 0.23, and between WPP and FST was -0.26. As with no-till, the correlation between GPMS and WPP was smaller than the correlation between GPMSA and WPP (0.81 vs 0.86, respectively).

Correlations between the grain yield traits and other agronomic traits, aside from FST, were similar for all three of the grain yield traits. Phenotypic correlation coefficients between grain yield and M were from 0.34 to 0.38 in no-till, and 0.36 to 0.38 in fall plow (Table 24). The corresponding genetic correlation coefficients were 0.47 to 0.54 in no-till, and 0.56 to 0.57 in fall plow. Higher yielding lines tended to have a higher percentage grain moisture at harvest. Higher yielding lines also tended to have a higher SG rating, indicating a larger percentage of green leaf tissue later in the season. Phenotypic correlations between the grain yield traits and SG ranged from 0.55 to 0.59 in no-till, and from 0.50 to 0.51 in fall plow. Correlation coefficients of similar magnitude and direction were observed between grain yield, and plant and ear heights (PHT and EHT). Larger plants tended to yield more grain, in each tillage system. The performance index (PFI) was also correlated with grain yield. Phenotypic and genetic correlations between lodging (PSL and PRL) and grain yield tended to be negative and nonsignificant for the no-till plots. In fall plow, grain yield was negatively correlated with PSL (-0.10 to -0.22), but positively correlated with PRL (0.19 to 0.25).

Significant positive phenotypic correlations between M and SG, M and PHT, M and EHT, SG and PHT, SG and EHT, and PHT and EHT were noted in both no-till and fall plow (Table 24). Taller S_1-lines tended to have higher ear placement, more green leaf tissue late in the season, and higher grain moisture at harvest time, irrespective of the tillage system in which they were grown. Phenotypic correlations between PSL and PHT, and between PSL and EHT, were larger in no-till than conventional tillage; that is, taller plants were more closely associated with increased incidence of stalk lodging in no-till than in fall plow. The performance index (PFI) was correlated with GPMS, GPMSA, WPP, PSL, and SG in no-till. PSL correlated highly with PFI (-0.81). In fall plow, GPMS, GPMSA, WPP, PSL, FST, SG, PHT, and EHT all were significantly correlated with PFI.

Correlations among vigor traits are listed in Table 25. The phenotypic correlations between vigor traits measured for the study were all significant at the 1% level for no-till. All the phenotypic correlations except the correlation between PEM and EPHT were significant at the 1% level for fall plow, and the correlation between PEM and EPHT was significant at the 5% level (0.23). Genetic correlations in each system indicated the same trends as the phenotypic correlations.

PEM was highly correlated with the visual EV trait, with a correlation coefficient of 0.59 in no-till, and 0.63 in fall plow.

Table 25. Correlations among early vigor traits in Experiment 1, for (a) no-till, and (b) fall plow. Coefficients above the diagonal are simple product moment correlations using entry-tillage means, and below the diagonal are genetic correlation coefficients

Trait	PEM	EV	EMI	EPHT	BMPP
	%	1-9	days	cm	cm
(a) Correlations in no-till					
PEM		0.59**	-0.27**	0.40**	0.84**
EV	0.60**		-0.31**	0.69**	0.77**
EMI	---[a]	---		-0.28**	-0.33**
EPHT	0.39**	0.77**	---		0.82**
BMPP	0.85**	0.82**	---	0.82**	
(b) Correlations in fall plow					
PEM		0.63**	-0.33**	0.23*	0.81**
EV	0.78**		-0.37**	0.50**	0.73**
EMI	---	---		-0.32**	-0.41**
EPHT	0.38**	0.70**	---		0.73**
BMPP	0.94**	0.88**	---	0.69**	

[a]Genetic correlations were not calculated, since significant variation was not present for one or both of the traits.

*,**Significant at the 5% and 1% level of probability, respectively.

PEM was negatively correlated with EMI, (-0.27 in no-till, -0.33 in fall plow), which indicated that faster emergence was associated with a higher percentage emergence. PEM was positively correlated with EPHT in each tillage system, the correlation coefficient being 0.40 in no-till, and 0.23 in fall plow. This association suggested that a greater percentage emergence was associated with faster early growth following emergence. PEM and BMPP were highly correlated; PEM was one of the two traits used to form the BMPP trait. Genetic correlations paralleled simple correlation values closely in both tillage systems.

Better early vigor, denoted by larger EV values, was correlated with smaller EMI, larger EPHT, and larger BMPP. EV was a visual rating trait that attempted to measure above ground plant matter and "greenness". The only possible difference in correlation coefficients noted between the two tillage systems was for the phenotypic correlation between EV and EPHT, which had a value of 0.69 in no-till, and a value of 0.50 in fall plow. The genetic correlations were more similar; the genetic correlation coefficient between EV and EPHT was 0.77 in no-till, and 0.70 in fall plow. The EV and BMPP traits measured similar characteristics, and were highly correlated. Genetic correlation coefficients were 0.82 in no-till, and 0.88 in fall plow.

EMI was negatively correlated with each vigor trait. More rapid emergence was associated with a larger PEM, taller EPHT, and greater BMPP. Genetic correlations involving EMI were not calculated due to the lack of significant genetic variation for EMI. No large differences in correlation coefficient values were noted between no-till and conventional tillage.

The phenotypic correlation coefficients between EPHT and the other vigor traits were somewhat larger in no-till than in fall plow. The genetic correlation coefficients did not differ much between the two tillage systems. The correlation between EPHT and BMPP was high; EPHT was one of the two traits used to form the BMPP measurement.

Table 26a lists the correlations between the pollen shedding and silking traits in no-till, and Table 26b lists the correlations for fall

Table 26. Correlations among pollen shedding and silking traits in Experiment 1, for (a) no-till, and (b) fall plow. Coefficients above the diagonal are simple product moment correlations using entry-tillage means, and below the diagonal are genetic correlation coefficients

	Trait				
Trait	PS2	SK2	PI	SKI	PSKI
	days	days	days	days	days
(a) Correlations in no-till					
PS2		0.89**	0.21*	0.29**	-0.10
SK2	0.92**		0.16	0.35**	0.36**
PI	0.30	0.17		0.27**	-0.09
SKI	---[a]	---	---		0.18
PSKI	-0.05	0.34**	-0.29**	---	
(b) Correlations in fall plow					
PS2		0.86**	-0.26**	-0.23*	-0.20*
SK2	0.90**		-0.20*	0.09	0.33**
PI	---	---		0.17	0.09
SKI	---	---	---		0.25*
PSKI	-0.11	0.34**	---	---	

[a]Genetic correlation coefficients were not calculated, since significant genotypic variation was not present for one or both of the traits.

*,**Significant at the 5% and 1% level of probability, respectively.

plow. The date for 50% pollen-shed was highly correlated with the date for 50% silk extrusion, with a phenotypic correlation coefficient of 0.89 in no-till, and a correlation coefficient of 0.86 in fall plow. PS2 and SK2 had small positive correlations with PI in no-till, and significant negative correlations in fall plow. A small negative correlation between PS2 and PSKI was observed in fall plow. Plants that shed pollen later in the season tended to have a shorter pollen-shedding-to-silk interval in fall plow. The correlation between SK2 and PSKI was the opposite direction; a later silking date was associated with a longer pollen-shedding-to-silk interval.

PI and SKI were significantly correlated in no-till, but the phenotypic correlation coefficient was small (0.27). The correlation in fall plow was positive, but not significant. No association between PI and PSKI was noted in either tillage system. The correlation between SKI and PSKI was positive, but not significant in no-till, and positive and significant in fall plow.

In no-till, all vigor traits except EMI displayed a significant positive correlation with GPMS (Table 27a). EMI and GPMS were negatively correlated, but not significantly. Between GPMSA and vigor traits in no-till, the only significant correlation was between GPMSA and EPHT. In fall plow, all five vigor traits were significantly correlated with GPMS (Table 27b). The direction of the correlations indicated that, for this group of genotypes, better early vigor was associated with higher GPMS.

In fall plow, correlations of GPMSA with EV, EMI, EPHT, and BMPP

Table 27. Correlations of agronomic traits with early vigor in Experiment 1, for (a) no-till, and (b) fall plow. Simple product moment correlation coefficients are listed, which were calculated using entry-tillage means

	Trait				
Trait	PEM	EV	EMI	EPHT	BMPP
	%	1-9	days	cm	cm
(a) Correlations in no-till					
GPMS	0.30**	0.39**	-0.11	0.36**	0.41**
GPMSA	0.03	0.19	0.06	0.25*	0.17
WPP	-0.17	0.03	0.17	0.16	0.00
M	-0.09	-0.13	0.13	-0.23*	-0.19
PSL	-0.01	-0.01	-0.01	0.04	0.01
PRL	0.19	0.08	-0.12	0.25*	0.26*
PDE	0.04	0.13	-0.09	-0.01	0.04
FST	0.80**	0.60**	-0.45**	0.41**	0.74**
SG	-0.06	-0.07	0.12	-0.01	-0.04
PHT	0.01	0.12	-0.01	0.24*	0.16
EHT	0.04	0.16	-0.04	0.31**	0.21**
PFI	0.02	0.13	0.03	0.14	0.10
(b) Correlations in fall plow					
GPMS	0.28**	0.38**	-0.25*	0.25*	0.37**
GPMSA	0.19	0.32**	-0.20*	0.23*	0.29**
WPP	-0.23*	0.02	0.06	0.14	0.06
M	-0.07	-0.02	0.09	-0.12	-0.10
PSL	0.12	-0.16	0.24*	-0.21*	-0.19
PRL	0.11	0.12	-0.10	0.18	0.17
PDE	-0.07	0.02	0.04	0.06	-0.04
FST	0.85**	0.57**	-0.50**	0.19	0.71**
SG	0.10	0.00	0.05	-0.02	-0.06
PHT	0.03	0.09	0.05	0.24*	0.19
EHT	0.01	0.07	0.01	0.29**	0.19
PFI	0.21*	0.33**	-0.30**	-0.30**	-0.33**

*,**Significant at the 5% and 1% level of probability, respectively.

were significant, and similar to those with GPMS. Vigor traits were highly correlated with FST in each tillage system. In no-till, all five vigor traits were correlated with FST. The largest correlation coefficient was 0.80 between PEM and FST, and the smallest 0.43, between EPHT and FST. In fall plow, all vigor traits except EPHT were significantly correlated with FST. The phenotypic correlation coefficient between FST and PEM was 0.85 in fall plow. EPHT was significantly correlated with PHT and EHT in both tillage systems. Plants which were taller at the time when EPHT measurements were taken tended to be taller at maturity.

PFI was correlated with none of the vigor traits in no-till, and with all of the vigor traits in fall plow. The GPMSA grain yield trait was used to calculate PFI, and adjustment of yield for stand nullified correlations between grain yield and vigor traits in no-till, but not in fall plow.

Correlations between agronomic traits and pollen shedding and silking traits are listed in Table 28. For no-till, a later date for PS2 and SK2 was correlated with higher GPMSA, WPP, M, PSL, SG, PHT, and EHT. A negative correlation with FST was observed. In fall plow, larger PS2 and SK2 values were correlated with larger GPMS, GPMSA, WPP, M, SG, PHT, and EHT. The phenotypic correlation coefficients of PS2 and SK2 with agronomic traits were similar in direction and magnitude for the two tillage systems. PI had no strong correlations with agronomic traits in either system. SKI was not significantly correlated with any of the agronomic traits in no-till, but in fall plow, exhibited

Table 28. Correlations of agronomic traits with pollen shedding and silking traits in Experiment 1, for (a) no-till, and (b) fall plow. Simple product moment correlation coefficients are listed, which were calculated using entry-tillage means

	Trait				
Trait	PS2	SK2	PI	SKI	PSKI
	days	days	days	days	days
(a) Correlations in no-till					
GPMS	0.18	0.15	0.11	0.17	-0.04
GPMSA	0.29**	0.22*	0.12	0.17	-0.12
WPP	0.36**	0.25*	0.11	0.14	-0.17
M	0.47**	0.48**	0.03	0.18	0.10
PSL	0.21*	0.14	0.21*	-0.01	-0.13
PRL	-0.05	0.01	-0.01	-0.08	0.13
PDE	0.12	0.11	0.01	0.02	-0.01
FST	-0.25*	-0.14	-0.03	-0.05	0.20
SG	0.49**	0.47**	0.07	0.13	0.02
PHT	0.54**	0.49**	0.16	0.17	-0.03
EHT	0.47**	0.42**	0.24*	0.08	-0.04
PFI	-0.03	-0.04	-0.08	0.09	-0.01
(b) Correlations in fall plow					
GPMS	0.29**	0.25*	-0.11	-0.41**	-0.06
GPMSA	0.31**	0.25*	0.11	-0.41**	-0.08
WPP	0.35**	0.26*	-0.10	-0.34**	-0.16
M	0.45**	0.50**	0.04	-0.10	0.12
PSL	0.14	0.09	-0.04	0.06	-0.09
PRL	0.02	-0.04	-0.09	-0.04	-0.11
PDE	-0.12	-0.12	-0.01	-0.04	-0.01
FST	-0.09	-0.03	-0.05	-0.19	-0.10
SG	0.52**	0.52**	-0.03	-0.26**	0.04
PHT	0.56**	0.48**	-0.19	-0.36**	-0.13
EHT	0.56**	0.50**	-0.12	-0.32**	-0.07
PFI	0.08	0.07	-0.05	-0.24*	-0.01

*,**Significant at the 5% and 1% level of probability, respectively.

significant negative correlations with GPMS, GPMSA, WPP, SG, PHT, EHT, and PFI. None of the agronomic traits exhibited significant correlations with PSKI in either of the two tillage systems.

Correlations of early vigor traits with pollen shedding and silking traits within each tillage system are shown on Table 29. In no-till, PS2 and SK2 were negatively associated with reduced PEM, EV, EPHT, and BMPP, and a slower (larger) EMI. Similar correlations, though smaller in magnitude, were observed in fall plow.

Table 29. Correlations of early vigor traits with pollen shedding and silking traits in Experiment 1, for (a) no-till, and (b) fall plow. Simple product moment correlation coefficients are listed, which were calculated using entry-tillage means

	Trait				
Trait	PS2	SK2	PI	SK1	PSKI
	days	days	days	days	days
(a) Correlations in no-till					
PEM	-0.36**	-0.26*	0.03	0.06	0.18
EV	-0.42**	-0.30**	0.06	0.06	0.20
EMI	0.23*	0.12	0.06	0.12	-0.21*
EPHT	-0.44**	-0.36**	0.07	-0.05	0.13
BMPP	-0.45**	-0.34**	0.10	0.03	0.18
(b) Correlations in fall plow					
PEM	-0.19	-0.12	0.06	-0.12	0.13
EV	-0.26**	-0.18	0.19	0.09	0.13
EMI	0.20*	0.14	0.01	0.19	-0.11
EPHT	-0.28**	-0.23*	0.18	0.01	0.09
BMPP	-0.28**	-0.19	0.15	-0.07	0.16

*,**Significant at the 5% and 1% level of probability, respectively.

Correlations of traits in no-till with traits in fall plow The correlations of agronomic traits measured in no-till with agronomic traits measured in fall plow indicated that the expression of a trait was similar in each tillage system (Table 30). The simple correlation coefficients, on the diagonal, were 0.70 or larger for GPMSA, GPMS, WPP, M, FST, SG, PHT, EHT, and PFI. Corresponding Spearman rank correlation coefficients were similar to the product moment correlation coefficients.

Table 31 lists the correlation of vigor traits measured in no-till with vigor traits measured in fall plow. These data provide insight relative to whether improving early vigor in fall plow would improve early vigor in a no-till system. The product moment correlations on the diagonal were positive and significant; however, correlations were only in the 0.40 to 0.60 range. The range of the rank correlations was from 0.34 for EMI to 0.58 for PEM. The rank correlation coefficients were slightly smaller than the corresponding product moment correlations.

The correlation of pollen-shedding and silking traits measured in no-till with the traits measured in fall plow are listed in Table 32. Correlations on the diagonal were significant for PS2, SK2, and PSKI, with simple product moment correlations of 0.73, 0.70, and 0.49, respectively. The corresponding Spearman rank correlations were very similar to the product moment correlation coefficients. The PI and SKI traits did not correlate across tillage systems.

Table 30. Phenotypic correlations in Experiment 1 of agronomic trait measurements in no-till with agronomic trait measurements in conventional tillage, using entry-tillage means. Simple product moment correlation coefficients are listed. The coefficients on the diagonal to the right of the slash mark are Spearman rank correlation coefficients

No-till traits	Fall plow traits			
	GPMS	GPMSA	WPP	M
	g/m^2	g/m^2	g	%
GPMS	0.78**/0.78**	0.77**	0.60**	0.38**
GPMSA	0.75**	0.77**/0.77**	0.73**	0.38**
WPP	0.69**	0.72**	0.80**/0.77**	0.35**
M	0.29**	0.32**	0.40**	0.78**/0.78**
PSL	-0.11	-0.12	-0.07	-0.02
PRL	0.12	0.11	0.07	-0.05
PDE	0.01	0.01	0.04	0.11
FST	0.24*	0.16	-0.20	0.09
SG	0.44**	0.46**	0.47**	0.50**
PHT	0.54**	0.55**	0.54**	0.30**
EHT	0.47**	0.49**	0.52**	0.28**
PFI	0.50**	0.51**	0.45**	0.16

*,**Significant at the 5% and 1% level of probability, respectively.

Fall plow traits			
PSL	PRL	PDE	FST
%	%	%	#/plot
-0.21*	0.16	-0.10	0.29**
-0.17	0.15	0.12	0.03
0.14	0.13	0.17	-0.14
0.00	0.05	0.06	-0.20
0.67**/0.56**	-0.18	-0.04	-0.01
0.01	0.12/0.26**	0.01	0.09
0.11	-0.20*	0.25*/0.22*	-0.05
-0.13	0.08	-0.08	0.70**/0.60**
-0.12	0.05	0.03	-0.05
0.11	0.16	-0.03	0.04
0.25*	0.08	0.02	-0.04
0.60**	0.21*	0.10	0.05

Table 30. (Continued)

No-till traits	Fall plow traits			
	SG	PHT	EHT	PFI
	1-9	cm	cm	
GPMS	0.49**	0.49**	0.45**	0.63**
GPMSA	0.52**	0.49**	0.46**	0.60**
WPP	0.53**	0.51**	0.46**	0.55**
M	0.42**	0.28**	0.30**	0.13
PSL	0.00	0.23*	0.39**	-0.48**
PRL	-0.03	0.10	0.19	0.07
PDE	0.14	0.00	0.06	-0.07
FST	0.06	0.11	0.10	0.18
SG	0.82**/0.80**	0.43**	0.36**	0.34**
PHT	0.51**	0.90**/0.90**	0.76**	0.28**
EHT	0.46**	0.71**	0.93**/0.92**	0.16
PFI	0.27**	0.10	-0.05	0.71**/0.66**

Table 31. Phenotypic correlations in Experiment 1, of early vigor trait measurements in no-till with early vigor trait measurements in conventional tillage, using entry-tillage means. Simple product moment correlation coefficients are listed. The coefficients on the diagonal to the right of the slash mark are Spearman rank correlation coefficients

	Fall plow traits				
No-till traits	PEM	EV	EMI	EPHT	BMPP
	%	1-9	days	cm	cm
PEM	0.62**/0.58**	0.25*	-0.30**	0.12	0.51**
EV	0.42**	0.40**/0.37**	-0.11	0.22*	0.47**
EMI	0.40**	-0.30**	0.40**/0.34**	0.25*	-0.45**
EPHT	0.21*	0.19	0.10	0.47**/0.46**	0.49**
BMPP	0.42**	0.24*	-0.25*	0.30**	0.57**/0.55**

*,**Significant at the 5% and 1% level of probability, respectively.

Table 32. Phenotypic correlations in Experiment 1, of pollen shedding and silking trait measurements in no-till with pollen shedding and silking traits measured in fall plow, using entry-tillage means. Simple product moment correlation coefficients are listed. The coefficients on the diagonal to the right of the slash mark are Spearman rank correlation coefficients

	Fall plow traits				
No-till traits	PS2	SK2	PI	SKI	PSKI
	days	days	days	days	days
PS2	0.73**/0.71**	0.58**	-0.26*	-0.28**	-0.24*
SK2	0.72**	0.70**/0.68**	-0.20*	-0.32**	0.00
PI	0.14	0.12	-0.05/-0.09	-0.14	-0.03
SKI	0.17	0.15	-0.12	-0.12/-0.13	-0.03
PSKI	0.09	0.35**	0.08	-0.13	0.49**/0.50**

*,**Significant at the 5% and 1% level of probability, respectively.

Table 33a lists the correlations of vigor traits as measured in fall plow with agronomic traits measured in no-till. PEM, EV, and BMPP were significantly and positively correlated with GPMS. For GPMSA, the correlations of early vigor traits in fall plow with no-till grain yields were not significant. Early vigor traits, as measured in fall plow, generally had significant correlations with FST measured in no-till, EPHT being the exception. Better early vigor in fall plow was associated with larger FST in no-till.

The inverse situation, the correlation of vigor traits measured in no-till with agronomic traits measured in conventional tillage, is listed in Table 33b. EV had significant, but small, correlations with GPMS and GPMSA (0.24 and 0.20, respectively, were the correlation coefficients), and both EPHT and BMPP were weakly correlated with GPMS. Early vigor traits in no-till, were correlated with FST in fall plow, with the exception of EPHT. Better no-till vigor was associated with higher FST in conventional tillage.

Selection of lines

Four different criteria were used as a basis for selection of lines. Grain yield (GPMS), grain yield adjusted for stand (GPMSA), and selection indices all were feasible selection criteria, depending on the goals of selection. Each method will be reported separately.

Selection was done within each set of lines, with equal numbers being selected from each set. With a 10% selection intensity, and 20 lines per set, 2 lines were selected from each of the five sets, from each tillage system, for a total of 10 lines from each tillage system.

Table 33. Phenotypic correlations in Experiment 1 of (a) agronomic traits measured in no-till with early vigor traits measured in fall plow, and (b) agronomic traits measured in fall plow with early vigor traits measured in no-till, using entry-tillage means. Simple product moment correlation coefficients are listed

No-till traits	Fall plow traits				
	PEM	EV	EMI	EPHT	BMPP
	%	1-9	days	cm	cm
(a) No-till agronomic traits with fall plow vigor traits					
GPMS	0.25*	0.26**	-0.18	0.16	0.31**
GPMSA	0.00	0.12	-0.02	0.13	0.11
WPP	-0.18	0.03	0.05	0.15	-0.02
M	-0.20*	0.13	0.06	-0.22*	-0.27**
PSL	-0.02	-0.06	0.16	-0.07	-0.03
PRL	0.04	0.04	-0.22*	0.25*	0.20*
PDE	-0.02	-0.09	0.11	-0.12	0.08
FST	0.72**	0.37**	-0.41**	0.10	0.59**
SG	-0.10	0.02	-0.05	-0.05	-0.09
PHT	-0.02	0.04	0.04	0.16	0.12
EHT	-0.05	0.02	0.08	0.18	0.10
PFI	0.04	0.13	-0.13	0.14	0.11
Fall plow traits	No-till traits				
(b) Fall plow agronomic traits with no-till vigor traits					
GPMS	0.16	0.24*	-0.13	0.20*	0.23*
GPMSA	0.09	0.20*	-0.09	0.18	0.18
WPP	-0.18	0.02	0.14	0.08	-0.05
M	0.02	0.00	0.03	-0.04	-0.01
PSL	-0.13	-0.10	0.12	-0.04	-0.10
PRL	0.05	0.10	0.03	0.10	0.08
PDE	-0.05	0.05	0.07	-0.02	-0.06
FST	0.52**	0.36**	-0.40**	0.19	0.43**
SG	-0.05	0.04	0.01	0.10	0.04
PHT	0.02	0.11	-0.08	0.22*	0.15
EHT	0.01	0.11	-0.11	0.29**	0.17
PFI	0.14	0.20	-0.14	0.16	0.18

*,**Significant at the 5% and 1% level of probability, respectively.

Likewise, with a 20% selection intensity, 4 lines were selected per set, for a total of 20 per tillage system. The entry numbers of the lines selected for each of the four selection criteria are listed in Table 34.

With a 10% selection intensity for GPMS, 3 lines were in common for the selected groups (Table 34). With a 20% selection intensity, 10 of the 20 lines per group were common to both groups. The mean of the fall plow selections in the fall plow system was 471 g/m^2 with a 10% selection intensity, and 461 g/m^2 with a 20% selection intensity (Table 35). The group selected using a 10% selection intensity for GPMS in no-till had a mean yield of 439 g/m^2 in the fall plow plots, and the 20% selection intensity group had a mean yield of 431 g/m^2 in fall plow. The mean of the FP selections evaluated in FP were compared with the mean of the NT selections evaluated in FP by using an LSD, and the 10% selection intensity group means were significantly different at the 5% level of probability. The 20% selection intensity group means were significantly different at the 1% level.

The performance of the same selection groups evaluated in no-till is reported in Table 36. The mean grain yield of the no-till 10% selection intensity group evaluated in no-till was 432 g/m^2, and the mean grain yield of the fall plow 10% selection intensity group evaluated in no-till was 386 g/m^2. The difference between the two groups was 46 g/m^2, and was significant at the 1% level. The mean grain yield of the no-till 20% selection intensity group evaluated in no-till was 410 g/m^2, and the mean of the fall plow 20% selection intensity group evaluated in no-till was 389 g/m^2. These two values were not significantly different at the 5% level.

Table 34. Entry numbers of genotypes selected in no-till (NT) and fall plow (FP), with four different selection criteria for Experiment 1

Selection		Selection criterion							
		GPMS		GPMSA		SHI		PFI	
Set	Rank	NT	FP	NT	FP	NT	FP	NT	FP
		g/m^2		g/m^2					
1	1	6	19	18	19	6	11	16	11
	2	18	8	6	18	16	19	13	18
	3	16	18	16	6	18	8	15	19
	4	13	11	13	8	20	6	19	15
2	1	23	35	35	35	23	23	35	36
	2	35	36	23	36	35	35	23	35
	3	24	23	24	23	24	32	36	23
	4	37	24	37	24	36	28	24	24
3	1	44	59	44	59	44	59	42	59
	2	58	44	50	52	42	44	50	42
	3	42	52	42	44	58	42	59	44
	4	50	50	54	50	50	52	48	53
4	1	79	78	80	78	79	80	79	80
	2	78	80	79	80	78	78	80	74
	3	76	72	78	72	76	76	61	78
	4	61	76	76	76	69	65	68	72
5	1	98	88	98	88	98	98	98	98
	2	92	82	92	82	92	88	90	88
	3	97	98	97	98	97	93	82	82
	4	88	93	90	93	88	82	92	92
# in common:									
10% selection		3/10		3/10		5/10		4/10	
20% selection		10/20		11/20		9/20		12/20	

Table 35. Mean fall plow grain yields of groups selected in no-till (NT) and fall plow (FP), based on GPMS and GPMSA, for Experiment 1

Selection criterion	Selection intensity	FP selection in FP	NT selection in FP	Difference
		g/m^2	g/m^2	g/m^2
GPMS	10%	471	439	32*
	20%	461	431	30**
GPMSA	10%	471	440	31*
	20%	459	429	30**

*,**Significant difference at the 5% and 1% level of probability, based on an LSD comparison.

Table 36. Mean no-till grain yields of groups selected in no-till (NT) and fall plow (FP), based on GPMS and GPMSA, for Experiment 1

Selection criterion	Selection intensity	NT selection in NT	FP selection in NT	Difference
		g/m^2	g/m^2	g/m^2
GPMS, g/m^2	10%	432	386	46**
	20%	410	389	14
GPMSA, g/m^2	10%	422	382	40**
	20%	403	391	12

**A significant difference at the 1% level of probability, based on an LSD comparison.

A 10% selection intensity group and 20% selection intensity group were identified in each tillage system, with GPMSA as the criterion. Means for each of the four groups in each of the two tillage systems were calculated, and compared by the use of an LSD. Three of the 10 lines selected with a 10% selection intensity were common to the no-till and conventional tillage groups (Table 34). Eleven of the 20 lines selected with a 20% selection intensity were common to the no-till and conventional tillage groups.

When evaluated in fall plow, the fall plow 10% selection intensity group mean grain yield was 471 g/m^2 (Table 35), and the no-till 10% selection intensity group mean grain yield was 440 g/m^2. The difference between these two groups was 31 g/m^2, which was significant at the 5% level. The difference between the two 20% selection intensity groups as evaluated in fall plow was 30 g/m^2; this difference was significant at the 1% level.

The no-till 10% selection intensity group mean grain yield evaluated in no-till was 422 g/m^2 (Table 36). The corresponding fall plow selection group mean GPMS in no-till was 382 g/m^2. The difference, 40 g/m^2, was significant at the 1% level. The difference in mean no-till performance of the two 20% selection intensity groups was 12 g/m^2, which was not significant at the 5% level.

No significant genotype by tillage (G x T/S) interaction for GPMS or GPMSA was observed in a combined anova (Table 19); however, a different set of lines were selected in each tillage system. Only 30% of the genotypes in no-till and fall plow groups selected with a 10%

selection intensity were in common (Table 34), with either GPMS or GPMSA as the selection criterion. When a 20% selections intensity was used, 50% of the till-group selections were in common with GPMS as the selection criterion, and 55% were in common with GPMSA as the selection criterion.

Since genotypes were selected and evaluated with the same data, selected genotypes could have positive error effects associated with their measurement, causing inflated estimates of differences between the till-group selections to result. The differences among means displayed in Table 35 and 36 could have been due to associated positive error effects, rather than genetic effects. To alleviate this problem, genotypes were selected based on 1981 data, and evaluated with 1982 data. Likewise, the reverse was done, selecting genotypes based on 1982 data, and evaluating using the 1981 data. The method reduced the number of observations used for selection, but the problem with positive error effects was eliminated. In Table 37, GPMS was used as a selection criterion. Lines were selected based on 1981 performance and evaluated based on 1982 performance, and vice versa. A 10% selection intensity was used within each tillage system.

No-till selections out-performed their respective fall plow selections in every case, even for fall plow selections evaluated in fall plow plots. Lines which were selected in no-till had significantly higher yields than lines selected in fall plow, when evaluated in no-till plots. No-till selections had higher yields than fall plow selections, when evaluated in fall plow, but differences were not statistically significant.

Table 37. Grain yields of groups selected in one year and evaluated in the alternate year, for Experiment 1. Selection was based on GPMS, with a 10% selection intensity

Selection group and tillage system	Selection in 1981, evaluation in 1982		Selection in 1982, evaluation in 1981	
	1981	1982	1982	1981
	g/m^2	g/m^2	g/m^2	g/m^2
FP selection, in FP	521	379	472	429
NT selection, in FP	482	405	428	450
Advantage	39	-26	44	-21
NT selection, in NT	457	371	447	391
FP selection, in NT	397	330	414	334
Advantage	60	41*	33	57**
FP mean	405	370	370	405
NT mean	323	328	328	323

*,**Significant difference at the 5% and 1% level of probability, respectively, based on an LSD comparison.

Two types of index selection were used to examine the effect of selecting for multiple traits in no-till and conventional tillage upon the degree of similarity (or dissimilarity) between selected groups for the two tillage systems. A Smith-Hazel index (SHI) procedure with nonstandardized variables and equal economic weights was used. The traits selected for were GPMS, M, PSL, PRL, and BMPP. A 20% selection intensity was used. Out of 20 lines selected in each tillage system, 9 were in common to the two groups and 11 were unique (Table 34). Three selections were different from those obtained by GPMS selection in no-till, and five selections were different from the fall plow GPMS selections. The means for the two groups of selections in each tillage system for the traits under selection are shown in Table 38.

When SHI was used to select for multiple traits, the selection intensity for grain yield was not greatly altered in either tillage system. In Table 36, it was observed that a 20% selection intensity for GPMS alone produced a NT selection group mean of 410 g/m^2, and Table 38 indicates that the no-till group selected with a Smith-Hazel index had a group mean grain yield of 409 g/m^2 in no-till. A 20% selection intensity for GPMS alone produced a fall plow selection group mean grain yield of 461 g/m^2 (Table 36), whereas a mean of 452 g/m^2 was observed for the group selected with a Smith-Hazel index (Table 38).

Multiple trait selection also was accomplished with a performance index (PFI), in which heritabilities were used as b-values with non-standardized variables. The variables used were quintals/ha adjusted for stand (QPHA, = GPMSA/10), M, PSL, PRL, and PDE.

Table 38. Mean for five traits of groups selected using two different index selection methods, for each tillage system, in Experiment 1. A 20% selection intensity was applied

Selection criterion	Selection group and tillage system	GPMS	M	PSL	PRL	BMPP
		Trait				
		g/m^2	%	%	%	cm
Smith-Hazel index (SHI)	FP selection in FP	452	21.6	15.0	2.4	195
	NT selection in FP	432	21.7	14.8	1.4	188
	Difference	20	-0.1	0.2	1.0	7
	NT selection in NT	409	22.4	14.1	0.9	144
	FP selection in NT	382	21.9	13.4	1.2	139
	Difference	27	0.5	0.7	-0.3	5
Performance index (PFI)	FP selection in FP	450	21.6	13.2	1.9	184
	NT selection in FP	425	21.5	13.9	1.5	179
	Difference	25	0.1	-0.7	0.4	5
	NT selection in NT	385	21.9	9.6	0.7	131
	FP selection in NT	385	22.4	12.5	0.9	136
	Difference	0	-0.5	-2.9	-0.2	-5
Fall plow mean:		384	21.3	17.2	1.3	178
No-till mean:		326	21.8	15.2	0.8	130

With a 20% selection intensity for PFI, twelve of the 20 lines were in common for the two groups of selections (Table 34). When PFI was used as a criterion for selection, the increased effectiveness of selection for no-till grain yield in a no-till environment was not observed. The mean grain yield of the fall plow selections was equal to the mean of the no-till selections when evaluated in no-till (Table 38). The moisture (M) was 0.5 percentage units lower, and PSL was 2.9 percentage units lower for the group selected in no-till when evaluated in no-till. When evaluated in fall plow, the fall plow selections mean grain yield was 25 g/m higher. All other traits in fall plow were approximately equal for the two groups. Selection based on PFI did not select for improved early vigor as measured by BMPP, for either selection group, in either tillage system.

Experiment 2: S_1-lines from BS13(SCT)C6

Presentation of results from Experiment 2 will use the same format as for Experiment 1. The two experiments differed, in that Experiment 1 had 100 S_1-lines in each of the 5 environments, whereas Experiment 2 had only 40 S_1-lines (2 sets) in environments 1 and 2, and had those 40 lines plus an additional 60 S_1-lines (3 sets) in environments 3, 4, and 5. Thus, the degrees of freedom in the anova table differed from Experiment 1, and selection of lines from sets 3, 4, and 5 was based only on data collected in 1982.

Results for Experiment 2 were divided into sections involving: (1) analyses of variance, (2) correlations, and (3) selection of lines, as in Experiment 1.

Analysis of variance

The analyses of variance will be discussed in five subsections: (1) early vigor traits, (2) pollen shedding and silking traits, (3) mature plant traits, (4) harvest traits, and (5) within plot variability traits. The subplot analysis will not be discussed, as with Experiment 1, because sets were used only as an incomplete blocking effect.

Early vigor traits Percentage emergence (PEM), a visual early vigor rating (EV), a rate of emergence index (EMI), early plant height (EPHT), and a biomass per plot rating (BMPP) were measures of early vigor for this experiment. For all early vigor traits except BMPP, the environment (E) source of variation was significant in the combined anova over tillage systems (Table 39). The tillage (T) source was significant for EPHT and BMPP, and the T x E interaction was significant for PEM and EMI. The PEM mean was lower, the EV rating was lower, the rate of emergence was slower, and the BMPP ratings were smaller in 1981 than 1982 (Table 40). The EPHT mean, however, was larger in 1981 than in 1982. The 1981 Ames environment produced the most severe tillage effects upon early vigor. The PEM mean was reduced 27.6%, the EV rating mean was 2.7 units lower, the EMI mean was 9.3 days slower, the EPHT mean was reduced 42% (15.2 cm), and the BMPP mean was reduced 62% in no-till at Ames in 1981, relative to the fall plow means. Nashua in 1981 was the second most severe environment, in terms of tillage effects on early vigor.

The genotype (G/S) and genotype by environment (G x E/S) sources

Table 39. The combined analysis of variance, over environments and tillage systems, for early vigor traits in Experiment 2

Source of variation	df	Trait				
		PEM	EV	EMI	EPHT	BMPP
		%	1-9	days	cm	cm
Environments (E)	4	117704.03**	597.70**	679.51*	5644.25**	226844
Replications (R)/E	5	998.71	13.20	60.49	363.10	46594
Tillage (T)	1	2312.42	127.12	2958.88	9771.28**	711933*
T x E	4	7650.78*	83.41	2114.98**	2158.72	217543
Error a (T x R/E)	5	1227.22	27.86	12.47	505.14	53147
Sets (S)	4	534.52	13.76*	10.96	54.31	10753
S x E	10	382.24*	9.81	13.72	80.82	11137
S x T	4	230.98	2.37	1.65	50.35	6803
S x T x E	10	120.32	1.91	4.56	62.05	5754
Error b (pooled error)	28	155.16	5.04	16.17	48.02	5777
Genotypes (G)/S	95	449.06**	3.58**	15.13	31.57**	5154**
G x E/S	265	203.42**	1.47**	33.10**	12.84**	2105**
G x T/S	95	51.07	1.13	14.72	9.94*	1102
G x T x E/S	265	55.72**	0.91	19.88	7.25	910*
Error c (residual)	720	38.27	0.83	21.68	7.77	740

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 40. Environment, tillage, and environment-tillage means for early vigor traits in Experiment 2

Type of mean		Trait				
		PEM	EV	EMI	EPHT	BMPP
		%	1-9	days	cm	cm
Experiment mean, overall		75.0	5.5	19.1	19.9	161
Tillage means:	No-till (NT)	72.2	5.2	20.5	17.4	140
	Fall plow (FP)	77.3	5.8	17.7	22.4	183
Year means:	1981	50.1	3.2	21.6	23.3	143
	1982	91.2	6.1	18.4	18.2	166
Location means:	Nashua	66.8	4.5	20.4	20.1	126
	Ames	77.0	5.1	19.6	20.2	176
	Kanawha	86.3	5.8	18.4	20.7	181
Environment means:	Nashua 1981 (1)	40.4	2.9	22.3	23.8	99
	Ames 1981 (2)	59.8	3.5	20.8	22.8	186
	Kanawha 1982 (3)	86.3	5.8	18.4	20.7	181
	Nashua 1982 (4)	93.2	6.0	18.4	16.3	152
	Ames 1982 (5)	94.1	6.6	18.4	17.6	166
Environment-tillage means:	1-NT	40.9	2.4	29.4	18.0	75
	1-FP	39.9	3.3	15.3	29.6	123
	2-NT	46.0	2.1	25.5	21.2	102
	2-FP	73.6	4.8	16.2	36.4	270
	3-NT	88.4	6.1	18.7	20.6	183
	3-FP	84.1	5.5	18.1	20.7	178
	4-NT	92.1	5.7	18.6	14.7	135
	4-FP	94.3	6.2	18.3	18.0	169
	5-NT	93.7	6.2	18.6	15.1	141
	5-FP	94.5	7.0	18.3	20.1	190

of variation were significant for all of the early vigor traits except EMI, which did not have significant genotypic variation (Table 39). EPHT had a significant G x T/S interaction, and the G x T x E/S interaction was significant for PEM and BMPP. The ratios of the σ^2 estimate to the σ^2_G estimate ranged from 2.4 for PEM to 6.3 for EPHT, and ratios of the σ^2_{GE} estimate to the σ^2_G estimate ranged from 1.0 for EPHT to 2.6 for PEM (Table 41). The H^2 estimates were very similar for the four vigor traits with significant genotypic variation.

All early vigor traits except EMI had significant E, G/S, and G x E/S sources of variation for the combined anova within no-till (Table 42a). EMI had no significant sources which involved genotypes. In the fall plow anova, PEM, EV, and EPHT had significant variation due to environments, PEM, EV, EPHT, and BMPP had significant genotypic variation, and all five vigor traits had significant G x E/S interactions (Table 42b). A tendency toward greater expression of genotypic variation for vigor traits in fall plow was observed, and for EPHT and BMPP, the difference between the estimates for the two tillage systems was more than 2 standard error units apart (Table 43). H^2 estimates tended to be greater for fall plow than no-till, but not a significant amount.

Pollen shedding and silking traits The pollen shedding and silking traits included 50% pollen shedding date (PS2), 50% silking date (SK2), pollen shedding interval (PI), silking interval (SKI), and pollen-shedding-to-silking interval (PSKI). The environments source of variation was significant for all five pollen shedding and silking

Table 41. Variance component estimates and heritability estimates from the combined analysis of variance, over environments and tillage systems, for (a) early vigor traits, and (b) pollen shedding and silking traits, in Experiment 2

Trait	σ^2_G	σ^2_{GE}	σ^2_{GT}	σ^2_{GTE}	σ^2	H^2
(a) Early vigor traits						
PEM, %	16.16 ± 4.40	41.29 ± 3.79	-0.61 ± 1.15	8.73 ± 2.29	38.27	0.61 ± 0.17
EV, 1-9	0.14 ± 0.03	0.16 ± 0.03	0.03 ± 0.02	0.04 ± 0.04	0.83	0.66 ± 0.16
EMI, days	-1.18 ± 0.24	2.86 ± 0.77	-0.92 ± 0.36	-0.90 ± 1.07	21.68	---[a]
EPHT, cm	1.23 ± 0.31	1.27 ± 0.26	0.29 ± 0.21	-0.26 ± 0.21	7.77	0.66 ± 0.16
BMPP, cm	201 ± 50	341 ± 40	25 ± 23	85 ± 39	740	0.61 ± 0.16
(b) Pollen shedding and silking traits						
PS2, days	2.46 ± 0.46	1.17 ± 0.22	0.04 ± 0.09	0.08 ± 0.22	3.42	0.86 ± 0.32
SK2, days	2.40 ± 0.46	1.25 ± 0.24	0.06 ± 0.11	0.49 ± 0.27	3.64	0.85 ± 0.33
PI, days	-0.01 ± 0.03	0.12 ± 0.09	-0.03 ± 0.07	0.32 ± 0.19	2.54	---
SKI, days	0.10 ± 0.07	0.07 ± 0.11	-0.20 ± 0.06	-0.19 ± 0.18	3.20	0.36 ± 0.49
PSKI, days	0.22 ± 0.08	0.20 ± 0.09	-0.10 ± 0.05	0.52 ± 0.16	2.16	0.60 ± 0.41

[a]No heritability estimate was calculated for this trait, since significant genotypic variation was not present.

Table 42. The combined analysis of variance for early vigor traits, within (a) the no-till system, and (b) the fall plow system, in Experiment 2

Source of variation	df	Trait				
		PEM	EV	EMI	EPHT	BMPP
		%	1-9	days	cm	cm
(a) Combined anova for no-till						
Environments (E)	4	73593.90**	451.99**	2594.75**	1452.97**	208118**
Replications (R)/E	5	36.17	10.50	28.48	69.86	2399
Sets (S)	4	283.50	3.23	5.68	15.94	2760
S x E	10	156.43	3.64	4.80**	21.06	2449
Error a (S x R/E)	14	256.80	5.96	1.19	35.76	5828
Genotypes (G)/S	95	244.30**	2.17**	8.76	15.18**	2101**
G x E/S	265	132.79**	1.17**	8.16	8.05**	1189**
Error b (residual)	360	45.35	0.75	10.00	5.78	576
(b) Combined anova for fall plow						
Environments (E)	4	51760.75**	229.13*	197.49	6350.01*	236270
Replications (R)/E	5	2189.76	30.56	44.48	798.38	97342
Sets (S)	4	482.00	12.90*	6.92	88.72	14797
S x E	10	346.14**	8.08	13.48	121.81	14441
Error a (S x R/E)	14	53.53	4.12	31.16	60.28	5725
Genotypes (G)/S	95	255.83**	2.54**	20.76	26.33**	4154**
G x E/S	265	126.35**	1.21**	40.67*	12.04*	1836**
Error b (residual)	360	31.19	0.91	33.35	9.76	903

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 43. Variance component estimates and heritability estimates, from the combined analysis of variance, within each tillage system for Experiment 2. Estimates for (a) early vigor traits, and (b) pollen shedding and silking traits, are listed

	No-till estimates				Fall plow estimates			
Trait	σ^2_G	σ^2_{GE}	σ^2	H^2	σ^2_G	σ^2_{GE}	σ^2	H^2
(a) Early vigor traits								
PEM, %	14.67	132.79	45.35	0.52	17.04	47.58	31.19	0.57
EV, 1-9	0.13	0.21	0.75	0.53	0.18	0.15	0.91	0.59
EMI, days	-0.41	-0.96	10.00	--[a]	-2.63	3.86	33.35	--
EPHT, cm	0.94	1.14	5.78	0.54	1.88	1.14	9.76	0.61
BMPP, cm	120	307	576	0.50	306	462	903	0.63
(b) Pollen shedding and silking traits								
PS2, days	1.42	1.42	4.02	0.67	1.06	0.99	2.83	0.69
SK2, days	1.54	1.22	4.31	0.69	0.89	1.77	2.97	0.58
PI, days	0.02	0.27	2.69	--	-0.05	0.30	2.39	--
SKI, days	0.00	-0.04	3.22	--	0.05	0.02	3.18	--
PSKI, days	0.12	0.05	2.30	0.33	0.06	0.59	2.03	--

[a]Estimate not calculated, due to the lack of significant genotypic variation.

S.E. for σ^2_G	$\frac{NT\sigma^2_G - FP\sigma^2_G}{S.E.\ for\ \sigma^2_G}$	S.E. for σ^2_{GE}	S.E. for H^2
4.95	-0.48	5.78	0.13
0.05	-1.00	0.06	0.18
0.39	--	1.33	--
0.41	-2.29	0.52	0.17
62	-3.00	71	0.17
0.38	0.95	0.29	0.21
0.39	1.67	0.33	0.21
0.07	--	0.17	--
0.08	--	0.19	--
0.08	0.75	0.15	--

traits in the combined anova over tillage systems (Table 44). The tillage source was significant for PS2, SK2, and PSKI. Significant genotypic variation was noted for all traits except PI, and G x E/S was significant for PS2, SK2, and PSKI. The G x T x E/S interaction was significant for SK2, PI, and PSKI. No-till means for PS2 and SK2 were 2.5 and 3.0 days later, respectively, than the fall plow means (Table 45). The no-till PI and SKI means were 0.5 days longer than the means for fall plow, and the PSKI no-till mean was 0.4 days longer than the fall plow mean. PS2 and SK2 estimates for σ^2 were about 1.4 times larger than σ_G^2 estimates, and the σ_{GE}^2 estimates were only one-half as large as the σ_G^2 estimates (Table 41). The H^2 estimate over tillage systems was 86% for PS2 and 85% for SK2. Genotypic variation was not expressed for PI. SKI expressed relatively little genotypic variation, and the H^2 estimate was only 36%. The σ_G^2 and σ_{GE}^2 estimates for PSKI were about one-tenth the size of the σ^2 estimate, and the H^2 estimate was 60%.

For the combined anova within no-till, the environments source was significant for all five pollen shedding and silking traits, the G/S source was significant for PS2, SK2, and PSKI, and the G x E/S interaction was significant for PS2 and SK2 (Table 46a). In the fall plow anovas, the E source was significant for PI, SKI, and PSKI, the G/S source was significant for PS2 and SK2, and the G x E/S interaction was significant for PS2, SK2, PI, and PSKI (Table 46b).

The σ_G^2 estimates for PS2 and SK2 were 1.5 times greater in no-till, but estimates for σ^2 were also about 1.5 times greater in no-till

Table 44. The combined analysis of variance, over environments and tillage systems, for pollen shedding and silking traits in Experiment 2

Source of variation	df	Trait PS2	SK2	PI	SKI	PSKI
		days	days	days	days	days
Environments (E)	3	1182.83**	1138.61*	352.96**	349.26*	371.39**
Replications (R)/E	4	44.87	101.62	10.16	26.63	12.22
Tillage (T)	1	1787.13*	2520.16**	65.74	45.34	61.36**
T x E	3	586.81	676.60	23.72	3.61	3.53
Error a (T x R/E)	4	98.31	107.89	10.72	7.01	2.40
Sets (S)	4	11.66	33.45	14.68**	9.66	7.03
S x E	6	11.86	26.29	4.83	11.16*	4.31
S x T	4	19.83	18.01	2.93	3.41	4.85
S x T x E	6	10.85	9.72	1.33	1.65	4.18
Error b (pooled error)	20	18.68	25.73	2.83	2.21	3.12
Genotypes (G)/S	95	35.63**	35.50**	2.88	4.60**	5.44**
G x E/S	170	8.08**	8.64**	3.00	3.46	2.95**
G x T/S	95	3.81	4.93	3.01	2.37	2.09
G x T x E/S	170	3.58	4.62*	3.18*	2.83	2.66*
Error c (residual)	529	3.42	3.64	2.54	3.20	2.16

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 45. Environment, tillage, and environment-tillage means for pollen shedding and silking traits in Experiment 2

Type of mean			Trait			
		PS2	SK2	PI	SKI	PSKI
		days	days	days	days	days
Experiment mean, overall		92.6	94.4	4.5	4.2	1.8
Tillage means:	No-till (NT)	93.8	95.9	4.7	4.5	2.0
	Fall plow (FP)	91.3	92.9	4.2	4.0	1.6
Year means:	1981	94.8	97.0	5.6	5.3	2.2
	1982	91.7	93.4	4.0	3.8	1.7
Location means:	Nashua	96.3	96.7	6.8	6.6	0.4
	Ames	92.9	95.7	4.1	4.0	2.8
	Kanawha	90.8	92.6	4.2	3.7	1.8
Environment means:	Nashua 1981 (1)	96.3	96.7	6.8	6.6	0.4
	Ames 1981 (2)	93.2	97.2	4.3	4.0	4.0
	Kanawha 1982 (3)	90.8	92.6	4.2	3.7	1.8
	Nashua 1982 (4)	--[a]	--	--	--	--
	Ames 1982 (5)	92.6	94.1	3.8	3.9	1.5
Environment-tillage means:	1-NT	99.1	99.8	7.3	7.0	0.7
	1-FP	93.6	93.6	6.3	6.2	0.0
	2-NT	96.0	100.3	4.9	4.1	4.3
	2-FP	90.4	94.1	3.8	3.9	3.7
	3-NT	90.5	92.4	4.1	3.9	1.9
	3-FP	91.1	92.8	4.3	3.6	1.7
	4-NT	--	--	--	--	--
	4-FP	--	--	--	--	--
	5-NT	94.2	96.1	4.2	4.2	1.8
	5-FP	90.9	92.2	3.5	3.7	1.2

[a]Data for these traits were not collected at all environments.

Table 46. The combined analysis of variance for pollen shedding and silking traits, within (a) the no-till system, and (b) the fall plow system, in Experiment 2

Source of variation	df	Trait				
		PS2	SK2	PI	SKI	PSKI
		days	days	days	days	days
(a) Combined anova for no-till						
Environments (E)	3	1596.71**	1727.78**	220.21*	205.81*	182.36**
Replications (R)/E	4	36.78	57.58	17.79	18.98	9.08
Sets (S)	4	2.48	1.64	7.70	7.17	2.59
S x E	6	8.20	17.50	2.89	4.43	5.79
Error a (S x R/E)	10	18.38	22.08	3.86	2.19	2.02
Genotypes (G)/S	95	22.71**	23.96**	3.46	3.21	3.69**
G x E/S	170	6.85**	6.75**	3.22	3.15	2.39
Error b (residual)	265	4.02	4.31	2.69	3.22	2.30
(b) Combined anova for fall plow						
Environments (E)	3	172.91	87.13	156.37**	147.02*	192.51**
Replications (R)/E	4	106.43	152.04	3.08	14.66	5.54
Sets (S)	4	29.04	49.86	9.92*	5.91	9.28
S x E	6	14.50	18.46	3.27	8.38*	2.70
Error a (S x R/E)	10	18.98	29.38	1.80	2.22	4.21
Genotypes (G)/S	95	16.73**	16.47**	2.44	3.79	3.85
G x E/S	170	4.81**	6.51**	2.98*	3.14	3.21**
Error b (residual)	265	2.83	2.97	2.39	3.18	2.03

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

(Table 43). The H^2 estimates were 67% and 69% for PS2, and 69% and 58% for SK2, in no-till and fall plow, respectively. PI and SKI had no significant genotypic variation expressed. PSKI had a significant genotypic variation in no-till, but the σ^2_G estimate was relatively small; the H^2 estimate in no-till was 33%. Significant genotypic variation for PSKI was not expressed in the fall plow anova.

<u>Mature plant traits</u> Traits measured after anthesis and silking, and prior to harvest, included plant height (PHT), ear height (EHT), and stay green (SG). For PHT and EHT, the E, T, G/S, and G x E/S sources were significant in the combined anova over tillage systems (Table 47). Plant height was reduced 11 cm in no-till, and ear height was reduced 7 cm in no-till (Table 48). The estimates for σ^2_G were large, relative to the estimates for σ^2_{GE} and σ^2, and H^2 estimates over tillage systems were 94% and 90% for PHT and EHT, respectively (Table 49).

The E, G/S, and G x E/S sources of variation for PHT and EHT were significant in the anovas within each tillage system (Table 50). The EHT trait σ^2 estimate was twice as large in no-till as in fall plow (Table 51). The H^2 estimates for PHT were nearly equal for the two tillage systems; 91% in no-till and 90% in fall plow. For EHT, the H^2 estimate was somewhat larger in fall plow than no-till; 90% vs 80%, respectively.

Stay green (SG) had significant variation only for G/S and G x E/S in the combined anova over tillage systems (Table 47). No trends for the effects of tillage on SG were noted; in three environments, the

Table 47. The combined analysis of variance, over environments and tillage systems, for mature plant traits in Experiment 2

Source of variation	df	Trait PHT	EHT	SG
		cm	cm	1-9
Environments (E)	4	69248**	30854**	167.01
Replications (R)/E	5	2437	1698	40.58
Tillage (T)	1	50209**	22143*	7.84
T x E	4	5301	671	59.33
Error a (T x R/E)	5	1878	1982	18.18
Sets (S)	4	2398*	1522	13.50
S x E	10	219	2019	11.02**
S x T	4	517	1732	1.08
S x T x E	10	336	1712	1.61
Error b (pooled error)	28	668	2039	2.58
Genotypes (G)/S	95	1592**	1328**	19.35**
G x E/S	265	128**	165**	4.24**
G x T/S	95	77	95	1.04
G x T x E/S	265	74	97	1.10
Error c (residual)	720	69	93	1.00

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 48. Environment, tillage, and environment-tillage system means for mature plant traits in Experiment 2

Type of mean		Trait	
	PHT	EHT	SG
	cm	cm	1-9
Experiment mean, overall	190	90	4.2
Tillage means: No-till (NT)	184	87	4.1
Fall plow (FP)	195	94	4.2
Year means: 1981	174	82	4.3
1982	194	93	4.1
Location means: Nashua	190	92	4.9
Ames	172	80	3.4
Kanawha	206	99	4.4
Environment means: Nashua 1981 (1)	184	84	5.1
Ames 1981 (2)	164	79	3.4
Kanawha 1982 (3)	206	99	4.4
Nashua 1982 (4)	196	99	4.7
Ames 1982 (5)	179	81	3.3
Environment-tillage means: 1-NT	177	79	5.9
1-FP	191	90	4.4
2-NT	168	73	3.6
2-FP	160	84	3.2
3-NT	202	96	4.0
3-FP	210	102	4.8
4-NT	188	97	4.9
4-FP	205	101	4.5
5-NT	171	76	2.9
5-FP	188	86	3.7

Table 49. Variance component estimates and heritability estimates from the combined analysis of variance, over environments and tillage systems, for (a) mature plant traits, and (b) harvest traits, in Experiment 2

Trait	σ^2_G	σ^2_{GE}	σ^2_{GT}	σ^2_{GTE}	σ^2	H^2
(a) Combined anova for mature plant traits						
PHT, cm	96 ± 15	15 ± 3	0 ± 2	3 ± 3	69	0.94 ± 0.15
EHT, cm	77 ± 13	18 ± 3	0 ± 2	2 ± 4	93	0.90 ± 0.15
SG, 1-9	0.99 ± 0.18	0.81 ± 0.08	-0.01 ± 0.02	0.05 ± 0.05	1.00	0.82 ± 0.15
(b) Combined anova for harvest traits						
GPMS, g/m^2	1479 ± 364	2323 ± 286	206 ± 150	-97 ± 251	5670	0.66 ± 0.16
GPMSA, g/m^2	1240 ± 290	1501 ± 215	328 ± 154	1 ± 230	5069	0.69 ± 0.16
WPP, g	53 ± 20	188 ± 23	-30 ± 17	226 ± 36	458	0.47 ± 0.18
M, %	2.67 ± 0.46	1.09 ± 0.15	-0.08 ± 0.07	0.01 ± 0.16	3.59	0.87 ± 0.15
PSL, %	40.00 ± 9.31	69.50 ± 6.60	5.88 ± 2.57	3.06 ± 3.62	75.76	0.69 ± 0.16
PRL, %	3.52 ± 1.75	22.84 ± 2.19	1.67 ± 1.14	8.01 ± 1.69	25.94	0.38 ± 0.19
PDE, %	0.00	0.00	0.00	0.00	0.30	---[a]
FST, #/plot	2.42 ± 0.97	11.59 ± 1.10	-0.94 ± 0.28	2.60 ± 0.73	12.57	0.45 ± 0.18

[a]No heritability estimate was calculated for this trait, since significant genotypic variation was not present.

Table 50. The combined analysis of variance for mature plant traits, within (a) the no-till system, and (b) the fall plow system, in Experiment 2

Source of variation	df	Trait PHT	EHT	SG
		cm	cm	1-9
(a) Combined anova for no-till				
Environments (E)	4	31053**	20266*	169.22
Replications (R)/E	5	606	2009	52.02
Sets (S)	4	1084*	2450	4.75
S x E	10	269	3485	3.64
Error a (S x R/E)	14	354	3588	1.56
Genotypes (G)/S	95	788**	732**	9.15**
G x E/S	265	93**	181**	2.64**
Error b (residual)	360	52	124	0.98
(b) Combined anova for fall plow				
Environments (E)	4	43496*	11259*	57.12*
Replications (R)/E	5	3709	1671	6.74
Sets (S)	4	1831	803	9.83
S x E	10	287	246	8.99
Error a (S x R/E)	14	983	489	3.60
Genotypes (G)/S	95	881**	691**	11.25**
G x E/S	265	109*	86**	2.71**
Error b (residual)	360	85	62	1.03

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 51. Variance component estimates and heritability estimates, from the combined analysis of variance, within each tillage system for Experiment 2. Estimates for (a) mature plant traits, and (b) harvest traits, are listed.

	No-till estimates				Fall plow estimates			
Trait	σ^2_G	σ^2_{GE}	σ^2	H^2	σ^2_G	σ^2_{GE}	σ^2	H^2
(a) Mature plant traits								
PHT, cm	91	21	52	0.91	102	12	85	0.90
EHT, cm	73	29	124	0.80	80	12	62	0.90
SG, 1-9	0.86	0.83	0.98	0.76	1.12	0.84	1.03	0.81
(b) Harvest traits								
GPMS, g/m^2	1473	2160	5470	0.60	1717	2390	5870	0.62
GPMSA, g/m^2	1202	1860	4576	0.59	1607	1143	5562	0.67
WPP, g	55	92	200	0.58	21	510	696	--[a]
M, %	2.87	1.21	3.47	0.84	2.38	1.15	3.43	0.81
PSL, %	43.98	68.36	70.76	0.68	41.90	73.78	80.61	0.65
PRL, %	1.04	11.88	8.47	0.24	7.67	41.82	43.40	0.38
PDE, %	0.00	0.01	0.38	--	0.00	-0.01	0.22	--
FST, #/plot	2.04	11.67	15.39	0.35	1.86	14.12	9.75	0.33

[a]Estimate not calculated, due to the lack of significant genotypic variation.

S.E. for σ^2_G	$\dfrac{NT\sigma^2_G - FP\sigma^2_G}{\text{S.E. for } \sigma^2_G}$	S.E. for σ^2_{GE}	S.E. for H^2
16	-0.69	5	0.15
14	-0.50	7	0.16
0.21	-1.24	0.12	0.17
438	-0.56	490	0.17
366	-1.11	397	0.17
25	--	49	--
0.49	1.00	0.28	0.15
10.58	0.20	9.84	0.16
2.31	-2.87	3.58	0.19
--	--	--	--
1.10	0.16	1.72	0.19

no-till SG mean was higher than the fall plow mean, whereas in the other two environments, the SG mean was higher in fall plow (Table 48). Estimates for σ^2_G, σ^2_{GE}, and σ^2 were of similar magnitude (0.99, 0.81, and 1.00, respectively), and the H^2 estimate was 82% (Table 49). The genotypes and genotype by environment sources of variation were significant for SG in the combined anova for the no-till system, and E, G/S, and G x E/S sources were significant in fall plow (Table 50). Estimates for σ^2 and σ^2_{GE} were very similar for the two tillage systems (Table 51), and the σ^2_G estimate was slightly greater in fall plow than in no-till (1.12 vs 0.86). The H^2 estimate was 76% in no-till, and 81% in fall plow.

Harvest traits The traits which were measured at or near harvest are those generally considered to be the most important. These included grain yield, grain moisture, stalk and root lodging, dropped ears, and final stand.

Three methods for evaluating grain yield were examined. Grain yield was evaluated as grams per square meter (GPMS), GPMS adjusted for stand differences (GPMSA), and grain weight per plant in grams (WPP). All three grain yield traits had significant effects due to E and T (Table 52). Environment means, tillage means, and environment-tillage means were equal for GPMS and GPMSA, because the yield adjustment for stand was done within an environment-tillage block. The overall experiment mean was 397 g/m^2 for GPMS, and 80 g/plant for WPP (Table 53). No-till grain yields were 21% lower for GPMS, as the no-till mean grain yield was 349 g/m^2, and the fall plow mean grain yield was 444

Table 52. The combined analysis of variance, over environments and tillage systems, for harvest traits in Experiment 2

Source of variation	df	Trait		
		GPMS	GPMSA	WPP
		g/m^2	g/m^2	g
Environments (E)	4	1171909**	1171907*	162547**
Replications (R)/E	5	102021	116472	2396
Tillage (T)	1	3358864*	3359226*	111740*
T x E	4	382017	381988	24786
Error a (T x R/E)	5	287751	251279	9876
Sets (S)	4	16351	12605	1251
S x E	10	16410	18536	2531**
S x T	4	11781	9031	942
S x T x E	10	14196	14507	2682**
Error b (pooled error)	28	17165	16861	584
Genotypes (G)/S	95	37449**	29924**	2019**
G x E/S	265	14962**	11073**	1209**
G x T/S	95	7232*	7565**	682
G x T x E/S	265	5477	5070	910**
Error c (residual)	720	5670	5069[a]	458

[a]Degrees of freedom associated with this error term are 717.

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Trait				
M	PSL	PRL	PDE	FST
%	%	%	%	#/plot
641.04*	119829.67**	11383.63**	4.00**	11270.32**
58.07	2659.46	232.66	0.14	170.40
23.07	7873.71	7032.98	0.27	852.75
107.50	5764.12**	3582.92**	1.80	1872.61**
26.89	343.72	22.02	0.21	54.06
42.98	1041.95	407.03	0.34	32.60
18.04*	663.35**	255.92**	0.34	71.57*
12.65	310.94	254.88**	0.28	51.52
24.07**	182.40	117.86	0.21	45.61
6.61	176.00	60.08	0.35	30.86
48.55**	961.82**	170.77**	0.32	95.78**
7.96**	353.77**	117.30**	0.27	58.94**
3.00	126.54**	54.68*	0.29	10.61
3.61	81.88	41.96**	0.29	17.77**
3.59	75.76	25.94	0.30	12.57

Table 53. Environment, tillage, and environment-tillage means for harvest traits in Experiment 2

Type of mean		GPMS	GPMSA	WPP	M	PSL	PRL	PDE	FST
		Trait							
		g/m^2	g/m^2	g	%	%	%	%	#/plot
Experiment mean, overall		397	397	80	26.4	21.3	3.9	0.1	43.6
Tillage means:	No-till (NT)	349	349	71	26.5	19.0	1.7	0.1	42.9
	Fall plow (FP)	444	444	88	26.3	23.6	6.0	0.1	44.4
Year means:	1981	402	402	110	25.7	4.8	0.5	0.2	33.6
	1982	395	395	72	26.6	25.7	4.8	0.1	46.3
Location means:	Nashua	394	394	99	26.1	26.0	7.0	0.1	38.0
	Ames	361	361	76	25.3	10.1	0.4	0.3	42.0
	Kanawha	481	481	60	28.4	14.5	0.6	0.0	46.1
Environment means:	Nashua 1981 (1)	418	418	129	26.6	1.6	0.9	0.1	30.2
	Ames 1981 (2)	385	385	91	24.7	8.0	0.1	0.2	36.9
	Kanawha 1982 (3)	481	481	88	28.4	14.5	0.6	0.0	46.1
	Nashua 1982 (4)	369	369	68	25.5	50.3	13.0	0.0	45.8
	Ames 1982 (5)	336	336	60	25.9	12.2	0.7	0.3	47.0
Environment-tillage means:	1-NT	386	386	105	28.2	1.2	0.5	0.0	31.7
	1-FP	450	450	154	25.1	2.0	1.3	0.1	28.6
	2-NT	305	305	91	25.1	5.1	0.2	0.1	29.9
	2-FP	465	465	90	24.2	10.8	0.0	0.3	44.0
	3-NT	468	468	86	28.2	14.1	0.3	0.1	45.9
	3-FP	494	494	89	28.7	15.0	0.9	0.0	46.3
	4-NT	338	338	62	25.5	41.9	5.7	0.0	45.4
	4-FP	400	400	73	25.6	58.8	20.3	0.0	46.1
	5-NT	246	246	44	25.8	13.8	0.2	0.4	46.9
	5-FP	426	426	76	25.9	10.6	1.1	0.2	47.1

g/m^2. Grain weight per plant was reduced 19% in no-till, as the no-till mean WPP was 71 g/plant, and the fall plow mean WPP was 88 g/plant. The environments with the greatest reduction for GPMS in no-till relative to fall plow were Ames 1981 and Ames 1982. At Ames in 1981, a 34.4% reduction, 160 g/m^2, was observed for the no-till mean, relative to the fall plow mean, and in 1982 at Ames, a 42.3% reduction of 180 g/m^2 (246 g/m^2 in no-till vs 426 g/m^2 in fall plow), was noted. No-till GPMS was lower than fall plow in every environment.

The largest tillage induced differences for WPP were observed at Nashua in 1981, and at Ames in 1982. At Nashua in 1981, the no-till mean WPP was 32% lower than the fall plow mean WPP, with means of 105 g/plant and 154 g/plant, respectively. And at Ames in 1982, a 42% reduction occurred in no-till relative to conventional tillage (44 g/plant vs 76 g/plant, respectively). However, very little difference in the WPP means for the two tillage systems was noted at Ames in 1981 and Kanawha in 1982. A large difference between the year means for WPP was observed. The 1981 WPP mean was 110 g/plant, and the 1982 WPP mean was 72 g/plant.

In the subsubplot anova for GPMS and GPMSA, the G/S, G x E/S, and G x T/S sources were significant (Table 52). For the WPP trait, G/S, G x E/S, and G x T x E/S sources were significant at the 1% level. The estimate for σ^2 was about 3.0 times larger than the estimates for σ^2_G for GPMS (5056 vs 1240, respectively) (Table 49). The estimates for σ^2_G, σ^2_{GE}, and σ^2 were all reduced for GPMSA, relative to the GPMS estimates. However, the σ^2_{GE} estimate was reduced proportionately more than the other two, and the H^2 estimate was 66% for GPMS, and 69% for GPMSA, across both tillage systems.

Genotypic variation expressed for WPP was small, relative to that expressed for GPMS and GPMSA (Table 49). The estimate for σ^2 was nearly 9 times greater than the estimate for σ_G^2 (458 vs 53, respectively), and the σ_{GE}^2 estimate was more than 3 times greater than the σ_G^2 estimate (188 vs 53, respectively). The H^2 estimate across tillage systems for WPP was 47%.

The E, G/S, and G x E/S sources of variation were all significant at the 1% level in the no-till combined anova for GPMS, GPMSA, and WPP (Table 54a). For the fall plow anovas, GPMS and GPMSA did not have significant effects due to environments, and for WPP, no genotypic variation was expressed (Table 54b). The σ_G^2 estimate for GPMS was somewhat larger in fall plow than in no-till (Table 51). The σ_{GE}^2 and σ_G^2 estimates were slightly smaller in no-till than in fall plow, and the H^2 estimate was 60% in no-till and 62% in fall plow. When GPMSA was used, variance component estimates were all smaller than for GPMS. The largest reduction was for the σ_{GE}^2 estimate in fall plow, which was reduced from 2390 for GPMS to 1143 for GPMSA, more than a 50% reduction. The H^2 estimates for GPMSA were 59% in no-till, and 67% in fall plow. WPP did not have a significant G/S source of variation in the fall plow anova (Table 54a). From variance component analysis (Table 51), it was observed that the σ^2 estimate was more than 3 times larger in fall plow than in no-till, and the σ_{GE}^2 estimate was 5.5 times larger in fall plow than in no-till. The σ_G^2 estimate calculated for no-till was 2.5 times

Table 54. The combined analysis of variance, within (a) the no-till system, and (b) the fall plow system, in Experiment 2

Source of variation	df	Trait GPMS	Trait GPMSA	Trait WPP
		g/m^2	g/m^2	g
(a) Combined anova for no-till				
Environments (E)	4	1312953**	1312915**	81726**
Replications (R)/E	5	34009	25835	1572
Sets (S)	4	1332	1353	80
S x E	10	19157	13365	564
Error a (S x R/E)	14	19509	19865	603
Genotypes (G)/S	95	20983**	17429**	825**
G x E/S	265	9790**	8296**	404**
Error b (residual)	360	5470	4576[a]	220
(b) Combined anova for fall plow				
Environments (E)	4	240973	240979	105607**
Replications (R)/E	5	355764	341916	10699
Sets (S)	4	26800	20283	2113
S x E	10	11448	19678	4650**
Error a (S x R/E)	14	14821	13857	566
Genotypes (G)/S	95	23698**	20060**	1876
G x E/S	265	10649**	7848**	1715**
Error b (residual)	360	5870	5562[b]	696

[a]Degrees of freedom associated with this error term are 358.

[b]Degrees of freedom associated with this error term are 359.

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Trait				
M	PSL	PRL	PDE	FST
%	%	%	%	#/plot
318.79**	39023.67**	1098.90**	3.70*	7466.34**
20.32	2369.47	87.83	0.32	101.16
44.25	302.29	36.31	0.28	20.52
26.04**	120.16	39.04**	0.26	59.67
6.48	209.42	8.05	0.44	44.12
27.71**	541.75**	40.14*	0.42	54.26**
5.88**	207.48**	32.23**	0.40	38.72**
3.47	70.76	8.47	0.38	15.39
429.75*	86569.12**	13867.66**	2.08**	5676.59**
64.64	633.71	166.84	0.02	123.30
11.38	1050.60	625.60	0.34	63.60
16.07	725.59**	334.74*	0.28	57.51**
6.74	142.59	114.04	0.25	1.76
23.84**	546.61**	185.31**	0.19	52.13*
5.73**	228.17**	127.04**	0.21	37.98**
3.43	80.61	43.40	0.22	9.75

larger than the fall plow estimate. The H^2 estimate for WPP in no-till was 58%; no estimate for H^2 was made in fall plow.

Grain moisture (M) had significant sources due to E, G/S, and G x E/S in the combined anova over tillage systems (Table 52). The effects of T, T x E, and interactions involving genotypes and tillage were not significant. The only environment in which tillage seemed to cause a major difference in M between the two systems was Nashua in 1981, where the no-till mean for M (28.2%) was 3.1% higher than the fall plow mean (25.1%) (Table 53). The σ^2 estimate obtained was 1.3 times larger than the σ_G^2 estimate (3.59 vs 2.67, respectively), and the σ_G^2 estimate was more than twice as large as the σ_{GE}^2 estimate (2.67 vs 1.09, respectively) (Table 49). The H^2 estimate over tillage systems was relatively high, 87%. In both the no-till and the fall plow analysis of variance, the effects due to E, G/S, and G x E/S were significant (Table 54). Estimates for σ^2, σ_{GE}^2, and σ_G^2 were similar for each tillage system, and the H^2 estimate was 84% in no-till, and 81% in fall plow (Table 51).

Percentage stalk lodging (PSL) and percentage root lodging (PRL) both had significant sources of variation due to E, T x E, G/S, G x E/S, and G x T/S in the combined anova over tillage systems (Table 52). Also, for PRL, the G x T x E/S interaction was significant. Large differences in lodging means occurred between the two years. In 1981, 4.8% stalk lodging and 0.5% root lodging was noted, and in 1982, 25.7% stalk lodging and 4.8% root lodging was noted (Table 53). Nashua in 1982 produced the greatest difference between the two tillage systems. Mean stalk lodging was 41.9% and mean root lodging was 5.7% in no-till, and the corresponding means for fall plow were 58.8% and 20.3%.

PSL had relatively more genotypic variation expressed than PRL (Table 49). The estimate for σ^2 was about 2 times greater than the σ_G^2 estimate for PSL, and 7.4 times greater for PRL. The heritability estimate over tillage systems for PSL was 69%, and for PRL was 38%.

The E, G/S, and G x E/S sources of variation were significant for both PSL and PRL in the anovas for each tillage system separately (Table 54). Estimates for σ^2, σ_{GE}^2, σ_G^2, and H^2 were similar in each tillage system for PSL (Table 51). Greater variation was expressed for PRL in fall plow than in no-till. The σ^2 estimate for PRL was about 5 times larger in fall plow, and the σ_G^2 estimate was more than 7 times greater in fall plow than no-till. The H^2 estimate was 24% for no-till, and 38% for fall plow.

Percentage dropped ears (PDE) was a trait of minor significance in this study. The analysis indicates that environments were a significant source of variation (Table 52), but the range of environment means was only from 0.0% to 0.3% (Table 53). No genotypic variation was noted in either the anova over tillage systems or the anovas within tillage systems (Tables 52, 54).

The E, T x E, G/S, G x E/S, and G x T x E/S sources of variation were all significant at the 1% level in the anova over tillage systems for final stand (FST) (Table 52). A considerable difference in mean FST was noted between 1981 and 1982 (33.6 vs 46.3, respectively) (Table

53). Stands were lower in no-till, relative to fall plow, within every environment. The greatest difference between the two tillage systems was at Ames in 1981, where the no-till FST was 29.9 plants/plot, and the fall plow FST was 44.0 plants/plot, which represented a 32% reduction in FST due to no-till. The σ^2 estimate and σ^2_{GE} estimate were each 5 times greater than the σ^2_G estimate (Table 49), and the H^2 estimate was 45%.

E, G/S, and G x E/S sources of variation were significant for the FST anova within each tillage system (Table 54). Estimates for σ^2, σ^2_{GE}, σ^2_G, and H^2 were similar for the two tillage systems. The H^2 estimate was 35% for no-till, and 33% for fall plow (Table 51).

Within plot variability traits Plant heights, ear heights, and early plant heights were measured on ten plants in each subsubplot. The within plot variance for these measurements was calculated. Standard errors for these variances were used in an anova (PHTS, EHTS, and EPHTS, respectively), and coefficients of variability were also used in an anova (PHTCV, EHTCV, and EPHTCV, respectively), to examine whether more within plot variability was observed in no-till than in fall plow.

Environments were significant for all 6 of the variability traits (Table 55). A significant effect due to tillage was noted only for the ear height coefficient of variability (EHTCV), and the early plant height coefficient of variability (EPHTCV). The plant height within plot standard error (PHTS) and ear height within plot standard error (EHTS) had significant T x E interactions. Means for PHTS, EHTS, and

Table 55. The combined analysis of variance, over environments and tillage systems, for within plot variability traits in Experiment 2

Source of variation	df	Trait					
		PHTS	EHTS	EPHTS	PHTCV	EHTCV	EPHTCV
		cm	cm	cm	%	%	%
Environments (E)	4	178.17**	468.66**	516.04**	149.85**	436.65**	3312.95*
Replications (R)/E	5	7.11	32.74	10.64	1.89	19.41	382.54
Tillage (T)	1	62.05	14.41	21.81	19.71	562.82*	3218.22*
T x E	4	84.74*	89.94*	23.05	7.16	147.18	964.37
Error a (T x R/E)	5	10.34	9.79	10.11	8.90	50.38	429.37
Sets (S)	4	134.50	93.33	2.93	19.60	87.22*	143.24
S x E	10	41.56*	22.04	3.69	12.44**	42.71	85.77
S x T	4	21.57	6.33	1.03	7.34	29.36	92.69
S x T x E	10	15.77	8.94	2.75	3.12	13.23	65.12
Error b (pooled error)	28	15.06	12.19	1.47	3.41	25.12	63.16
Genotypes (G)/S	95	41.15**	27.62**	2.51**	14.36**	56.80**	79.98**
G x E/S	265	14.64	13.12	1.33	4.57	19.28	48.03
G x T/S	95	21.61*	14.43	1.18	6.56*	21.72	40.86
G x T x E/S	265	17.97	12.55	1.59	5.58	18.63	46.05
Error c (residual)	720	15.79	12.44	1.67	4.84	18.23	52.17

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

early plant height within plot standard error (EPHTS) were actually slightly larger in fall plow than in no-till (Table 56). EHTCV and EPHTCV means were lower in fall plow.

Summary for the analysis of variance section for Experiment 2 Twenty-seven traits were examined in a combined analysis of variance, over environments and tillage systems (Tables 39, 44, 47, 52, and 55). Of these twenty-seven traits, seven exhibited significant genotype by tillage (G x T/S) interactions; EPHT, GPMS, GPMSA, PSL, PRL, PHTS, and PHTCV. Eight traits produced a significant G x T x E/S interaction: PEM, BMPP, SK2, PI, PSKI, WPP, PRL, and FST.

Significant effects due to tillage were observed for 12 of the traits, and a significant T x E interaction was observed for 7 of the traits. No trait had significant sources for both T and T x E. Twenty-four of the twenty-seven traits exhibited a significant genotypic (G/S) variation in a combined anova over tillage systems. Only EMI, PI, and PDE did not. Of these three, EMI had a significant G x E/S interaction.

Correlations among traits

For the correlations, traits were split into three groups: (1) agronomic traits, including GPMS, GPMSA, WPP, M, PSL, PRL, PDE, FST, SG, PHT, EHT, and the performance index described in the materials and methods section (PFI), (2) early vigor traits, including PEM, EV, EMI, EPHT, and BMPP, and (3) pollen shedding and silking traits, including PS2, SK2, PI, SKI, and PSKI.

Table 56. Environment, tillage, and environment-tillage means for within plot variability traits in Experiment 2

Type of mean		PHTS	EHTS	EPHTS	PHTCV	EHTCV	EPHTCV
		cm	cm	cm	%	%	%
Experiment mean, overall		14.1	12.7	3.9	7.5	14.5	20.3
Tillage means:	No-till (NT)	13.9	12.6	3.7	7.7	15.1	21.7
	Fall plow (FP)	14.3	12.8	4.1	7.4	13.8	18.8
Year means:	1981	14.6	11.4	6.2	8.5	14.3	25.3
	1982	14.0	13.1	3.3	7.3	14.5	18.9
Location means:	Nashua	14.8	13.4	4.6	7.9	15.1	23.2
	Ames	13.7	11.1	4.9	8.1	14.2	22.1
	Kanawha	14.3	13.1	3.4	7.0	13.4	17.0
Environment means:	Nashua 1981 (1)	15.9	13.0	6.0	8.8	15.8	26.9
	Ames 1981 (2)	13.2	9.8	6.3	8.2	12.7	23.7
	Kanawha 1982 (3)	14.3	13.1	3.4	7.0	13.4	17.0
	Nashua 1982 (4)	13.7	13.7	3.1	7.0	14.4	19.4
	Ames 1982 (5)	14.1	12.4	3.5	7.9	15.6	20.4
Environment-tillage means:	1-NT	15.9	13.8	5.3	9.1	17.8	30.1
	1-FP	15.9	12.1	6.7	8.4	13.8	23.6
	2-NT	13.9	10.1	5.6	8.3	13.9	27.6
	2-FP	12.6	9.6	7.0	8.0	11.6	19.8
	3-NT	14.5	13.3	3.3	7.2	14.0	16.3
	3-FP	14.1	12.9	3.5	6.7	12.8	17.8
	4-NT	13.0	13.0	3.2	7.0	14.3	21.8
	4-FP	14.4	14.5	3.0	7.1	14.6	17.0
	5-NT	13.5	12.1	3.1	7.9	16.3	21.4
	5-FP	14.6	12.6	3.8	7.9	15.0	19.4

Correlations within each tillage system The correlations among the agronomic traits will be discussed first. In no-till, the three yield traits were correlated (Table 57). However, the simple correlation between GPMS and WPP was only 0.59. The genotypic correlation was larger, 0.78. The three yield traits were negatively correlated with PSL. GPMS was positively correlated with FST, GPMSA was relatively uncorrelated, and WPP was negatively correlated. All three grain yield traits were correlated highly with the performance index (PFI). M was correlated with PRL and SG. PSL was positively correlated with FST, PHT, and EHT, and negatively correlated with SG and PFI. The genetic correlations were similar to the simple correlations, with few exceptions.

The correlations between the agronomic traits in fall plow are listed in Table 57b. In fall plow, correlations among the three grain yield traits were even lower than for no-till. The simple correlation between GPMS and WPP was 0.28, and the correlation between GPMSA and WPP was only 0.41. The grain yield traits were negatively correlated with PSL, and positively correlated with SG and PFI. As with the no-till correlations, GPMSA was not significantly correlated with FST, and WPP was negatively correlated with FST. M was positively correlated with PRL, SG, PHT, and EHT. PSL and PRL were positively correlated with FST, PHT, and EHT.

The correlations among the vigor traits are listed in Table 58a for no-till, and in Table 58b for fall plow. In no-till, BMPP was significantly correlated with the four other early vigor traits;

Table 57. Correlations among agronomic traits in Experiment 2, in (a) no-till, and (b) fall plow. Coefficients above the diagonal are simple product moment correlations using entry-tillage means, and below the diagonal are genetic correlation coefficients

Trait	GPMS	GPMSA	WPP	M	PSL
	g/m^2	g/m^2	g	%	%
(a) Correlations in no-till					
GPMS		0.94**	0.59**	-0.07	-0.23*
GPMSA	0.95**		0.72**	-0.05	-0.25*
WPP	0.78**	0.94**		0.07	-0.46**
M	-0.06	-0.03	0.03		-0.13
PSL	-0.37**	-0.39**	-0.34**	-0.02	
PRL	---[a]	---	---	---	---
PDE	---	---	---	---	---
FST	0.31**	0.02	-0.34**	0.03	0.12
SG	0.10	0.18	0.20	0.54**	-0.18
PHT	0.04	0.07	0.13	0.22*	0.41**
EHT	-0.08	-0.03	0.05	0.38**	0.42**

[a]Coefficient not listed due to lack of significant genotypic variation for at least one of the two traits involved.

*,**Significant at the 5% and 1% level of probability, respectively.

Trait						
PRL	PDE	FST	SG	PHT	EHT	PFI
%	%	#/plot	1-9	cm	cm	
0.07	0.06	0.26**	0.17	0.11	0.00	0.92**
0.10	0.03	0.09	0.20*	0.11	0.00	0.98**
0.02	-0.06	-0.59**	0.25*	-0.17	-0.06	0.76**
0.37**	-0.02	-0.14	0.50**	0.11	0.28**	-0.08
-0.01	0.03	0.40**	-0.22*	0.44**	0.33**	-0.42
	0.06	0.06	0.46**	0.24*	0.34**	0.06
---		0.15	-0.14	0.15	0.21*	0.02
---	---		-0.15	0.37**	0.10	0.01
---	---	-0.21*		0.02	0.21*	0.20*
---	---	-0.09	0.04		0.72**	0.01
---	---	-0.11	0.21	0.82**		-0.08

Table 57. (Continued)

Trait	Trait				
	GPMS	GPMSA	WPP	M	PSL
	g/m^2	g/m^2	g	%	%
(b) Correlations in fall plow					
GPMS		0.97**	0.28**	0.07	-0.29**
GPMSA	1.00**		0.41**	0.11	-0.34**
WPP	---	---		-0.05	-0.45**
M	0.11	0.17	---		0.03
PSL	-0.44**	-0.51**	---	-0.09	
PRL	-0.12	-0.10	---	0.72**	0.16
PDE	---	---	---	---	---
FST	0.23*	0.19	---	-0.14	0.29**
SG	0.31**	0.39**	---	0.48**	-0.40**
PHT	-0.11	-0.08	---	0.19	0.12
EHT	-0.14	-0.07	---	0.23*	0.19

Trait						
PRL	PDE	FST	SG	PHT	EHT	PFI
%	%	#/plot	1-9	cm	cm	
-0.05	0.04	0.30**	0.29**	0.01	-0.00	0.95**
-0.05	0.00	0.16	0.33**	0.00	0.00	0.98**
-0.23*	-0.04	-0.72**	0.16	-0.27**	-0.19	0.47**
0.49**	-0.13	0.11	0.47**	0.29**	0.30**	0.03
0.07	-0.10	0.36**	-0.23*	0.36**	0.26**	-0.48**
	-0.13	0.27**	0.52**	0.41**	0.46**	-0.13
---		-0.01	-0.05	-0.20*	-0.25*	0.03
-0.07	---		0.03	0.37**	0.25*	0.07
0.98**	---	-0.29**		0.11	0.25*	0.29**
0.43**	---	-0.28**	---		0.80**	-0.09
0.72**	---	-0.24*	---	---		-0.08

Table 58. Correlations among vigor traits in Experiment 2, in (a) no-till, and (b) fall plow. Coefficients above the diagonal are simple product moment correlations using entry-tillage means, and below the diagonal are genetic correlation coefficients

	Trait				
Trait	PEM	EV	EMI	EPHT	BMPP
	%	1-9	days	cm	cm
(a) Correlations in no-till					
PEM		0.83**	-0.82**	-0.19	0.84**
EV	0.37**		-0.77**	0.12	0.87**
EMI	---[a]	---		0.15	-0.69**
EPHT	0.02	0.68**	---		0.37**
BMPP	0.66**	0.79**	---	0.79**	
(b) Correlations in fall plow					
PEM		0.78**	0.46**	-0.54**	0.41**
EV	0.67**		0.35**	-0.21*	0.59**
EMI	---	---		-0.15	0.29**
EPHT	0.31**	0.66**	---		0.54**
BMPP	0.74**	0.89**	---	0.88**	

[a]Coefficient not listed, due to lack of significant genotypic variation for at least one of the two traits involved.

*,**Significant at the 5% and 1% level of probability, respectively.

negatively with EMI, and positively with the other three traits. EMI was also negatively correlated with PEM and EV. The only other significant simple correlation in no-till was between PEM and EV. The only early vigor trait in no-till which had a significant simple correlation with EPHT was BMPP. The genetic correlation coefficient between EPHT and EV was relatively large, 0.68. In fall plow (Table 58b), EPHT had significant negative correlations with PEM and EV, and EMI had significant positive correlations with PEM, EV, EPHT, and BMPP. The correlations with EMI were in the opposite direction relative to what would be expected and desired. Increased PEM was associated with slower emergence, and shorter early plant heights. Other correlations between vigor traits were in the desired directions. The genotypic correlations between EPHT and PEM, and EPHT and EV were in the correct direction, also.

Table 59a lists the correlation coefficients between the pollen shedding and silking traits in no-till, and Table 59b lists the coefficients between the traits in conventional tillage. PS2 and SK2 were highly correlated in each tillage system. PI was positively correlated with PS2, SK2, SKI, and PSKI in no-till, and correlated with PS2, SK2, and SKI in conventional tillage. The simple correlation coefficients were in general somewhat larger in no-till than in conventional tillage.

Simple correlations between the agronomic traits and early vigor traits are listed in Table 60a for no-till, and Table 60b for fall plow. Larger PEM and EV values were associated with decreased WPP, increased

Table 59. Correlations among pollen shedding and silking traits for Experiment 2, in (a) no-till, and (b) fall plow. Coefficients above the diagonal are simple product moment correlations using entry-tillage means, and below the diagonal are genetic correlation coefficients

	Trait				
Trait	PS2	SK2	PI	SKI	PSKI
	days	days	days	days	days
(a) Correlations in no-till					
PS2		0.94**	0.42**	0.06	0.02
SK2	0.95**		0.50**	0.13	0.34**
PI	---[a]	---		0.55**	0.31**
SKI	---	---	---		0.21*
PSKI	-0.06	0.26*	---	---	
(b) Correlations in fall plow					
PS2		0.89**	0.21*	-0.09	-0.25*
SK2	0.93**		0.25*	0.08	0.19
PI	---	---		0.45**	0.07
SKI	---	---	---		0.36**
PSKI	-0.32**	0.04	---	---	

[a]Coefficient not listed, due to lack of significant genotypic variation for at least one of the two traits involved.

*,**Significant at the 5% and 1% level of probability, respectively.

Table 60. Simple product moment correlations between agronomic traits and early vigor traits for Experiment 2, in (a) no-till, and (b) fall plow. Correlations based on entry-tillage means

	Trait				
Trait	PEM	EV	EMI	EPHT	BMPP
	%	1-9	days	cm	cm
(a) Correlations in no-till					
GPMS	0.16	0.28**	-0.07	0.43**	0.39**
GPMSA	0.07	0.23*	-0.05	0.38**	0.28**
WPP	-0.57**	-0.35**	0.52**	0.43**	-0.30**
M	0.12	-0.27**	0.23*	-0.30**	-0.29**
PSL	0.43**	0.39**	-0.40**	-0.18	0.31**
PRL	0.12	0.06	-0.11	-0.18	-0.01
PDE	0.18	0.19	-0.11	0.02	0.18
FST	0.91**	0.75**	-0.76**	-0.13	0.78**
SG	-0.16	-0.29**	0.22*	-0.21*	-0.29**
PHT	0.38**	0.30**	-0.40**	-0.04	0.32**
EHT	0.07	-0.03	-0.07	-0.11	0.00
PFI	-0.02	0.15	0.03	0.41**	0.22*
(b) Correlations in fall plow					
GPMS	0.16	0.31**	0.30**	0.21*	0.43**
GPMSA	0.07	0.25*	0.21*	0.18	0.31**
WPP	-0.64**	-0.40**	-0.67**	0.35**	-0.23**
M	0.12	0.00	0.12	-0.26**	-0.18
PSL	0.43**	0.28**	0.17	-0.46**	-0.06
PRL	0.29**	0.15	0.15	-0.42**	-0.16
PDE	-0.07	0.01	0.03	0.12	0.11
FST	0.86**	0.67**	0.61**	-0.41**	0.42**
SG	-0.01	-0.09	0.07	-0.18	-0.19
PHT	0.47**	0.38**	0.16	-0.41**	0.01
EHT	0.27**	0.11	0.15	-0.27**	-0.05
PFI	-0.03	0.18	0.15	0.28**	0.31**

*,**Significant at the 5% and 1% level of probability, respectively.

PSL, increased FST, and increased PHT, in both tillage systems. In addition, EV had a significant positive correlation with GPMS and GPMSA in each tillage system. EMI correlation coefficient values with the agronomic traits in no-till were of a similar magnitude as for EV, but correlations were in the opposite direction. In fall plow, EMI index was positively correlated with GPMS, GPMSA, and FST; these correlations were all in an undesirable direction. EPHT was positively correlated with GPMS, GPMSA, WPP, and PFI, and negatively correlated with M, PSL, PRL, and FST in both tillage systems. These associations were all in the direction which might produce favorable indirect responses to selection for increased EPHT. BMPP was positively correlated with GPMS, GPMSA, FST, and PFI in both tillage systems.

Simple correlations between the pollen shedding and silking traits and the agronomic traits measured are listed in Table 61. Table 61a lists the correlations in no-till, and Table 61b lists the correlations in fall plow. A later PS2 or SK2 date was associated with lower GPMS, GPMSA, FST, and PFI, and with higher M, SG, and EHT values, in each tillage system. Larger PI and SKI values were associated with increased WPP, and decreased PSL, FST, and PHT values in both tillage systems. No strong correlations with PSKI and any of the agronomic traits were observed.

The coefficients for the correlations between the pollen shedding and silking traits, and the vigor traits, are listed in Table 62a for no-till, and in Table 62b for fall plow. In general, for both tillage systems, increased vigor was negatively correlated with PS2 and SK2;

Table 61. Simple product moment correlations between agronomic traits and pollen shedding and silking traits for Experiment 2, in (a) no-till, and (b) fall plow. Correlations based on entry-tillage means

	Trait				
Trait	PS2	SK2	PI	SKI	PSKI
	days	days	days	days	days
(a) Correlations in no-till					
GPMS	-0.26**	-0.30**	-0.16	0.05	-0.11
GPMSA	-0.26**	-0.30**	0.11	0.06	-0.13
WPP	0.09	0.09	0.32**	0.44**	0.06
M	0.54**	0.59**	0.08	-0.14	0.23*
PSL	-0.12	-0.16	-0.22*	-0.35**	-0.19
PRL	0.19	0.16	-0.15	-0.20	-0.06
PDE	-0.01	-0.01	-0.09	-0.12	0.00
FST	-0.39**	-0.44**	-0.58**	-0.56**	-0.22*
SG	0.46**	0.47**	0.25*	0.05	0.13
PHT	0.09	0.06	-0.24*	-0.33**	-0.05
EHT	0.42**	0.40**	0.04	-0.13	0.04
PFI	-0.25*	-0.28**	-0.06	0.13	-0.09
(b) Correlations in fall plow					
GPMS	-0.18	-0.20*	-0.02	0.00	-0.01
GPMSA	-0.13	-0.15	-0.01	0.01	-0.01
WPP	0.07	0.05	0.17	0.17	-0.02
M	0.37**	0.39**	-0.08	-0.17	0.06
PSL	-0.05	-0.05	-0.30**	-0.25*	0.00
PRL	0.23*	0.24*	-0.20*	-0.33**	0.02
PDE	-0.15	-0.18	0.15	-0.01	-0.04
FST	-0.25*	-0.25*	-0.36**	-0.32**	-0.01
SG	0.36**	0.31**	-0.07	-0.24*	-0.15
PHT	0.20*	0.17	-0.31**	-0.31**	-0.04
EHT	0.41**	0.36**	-0.21*	-0.20*	-0.06
PFI	-0.14	-0.16	0.05	0.08	-0.02

*,**Significant at the 5% and 1% level of probability, respectively.

i.e., increased early vigor was associated with earlier pollen shedding and silking dates. Also, increased early vigor was generally associated with a smaller PI and SKI. In no-till, increased early vigor was generally correlated with a smaller PSKI, but for fall plow, no significant correlation between PSKI and early vigor was noted.

Table 62. Simple product moment correlations between early vigor and pollen shedding and silking traits for Experiment 2, in (a) no-till, and (b) fall plow. Correlations based on entry-tillage means.

	Trait				
Trait	PS2	SK2	PI	SKI	PSKI
	days	days	days	days	days
(a) Correlations in no-till					
PEM	-0.48**	-0.53**	-0.58**	-0.60**	-0.21*
EV	-0.65**	-0.69**	-0.56**	-0.49**	-0.25*
EMI	0.47**	0.52**	0.59**	0.62**	0.24
EPHT	-0.26**	-0.26**	0.09	0.33**	-0.04
BMPP	-0.63**	-0.67**	-0.51**	-0.38**	-0.22*
(b) Correlations in fall plow					
PEM	-0.30**	-0.31**	-0.47**	-0.42**	-0.03
EV	-0.49**	-0.49**	-0.50**	-0.28**	0.03
EMI	-0.03	-0.01	-0.08	-0.03	0.04
EPHT	-0.16	-0.12	0.39**	0.48**	0.12
BMPP	-0.51**	-0.49**	-0.08	0.09	0.07

*,**Significant at the 5% and 1% level of probability, respectively.

Correlations of traits in no-till with traits in fall plow The correlation of an agronomic trait measured in one tillage system to the same trait measured in the other tillage system generally produced correlation coefficients from 0.60 to 0.85 (Table 63). Correlations of the grain yield traits were near 0.60 to 0.65. The traits M, PSL, FST, SG, PHT, and EHT had correlation coefficients from 0.80 to 0.90 when no-till entry means were correlated with fall plow entry means. The traits PRL and PFI had coefficients in the 0.60 to 0.65 range for their correlations from no-till to fall plow.

Simple correlation coefficients of early vigor traits measured in no-till with their fall plow expression ranged from -0.22 to 0.92 (Table 64). PEM expression correlated well across tillage systems (near 0.90), the EV correlation coefficients were near 0.75, EPHT and BMPP correlated less well (near 0.55 and 0.40, respectively), and EMI actually was negatively correlated from one tillage system to the other.

The pollen shedding and silking traits correlations from no-till to fall plow are listed on Table 65. PS2 and SK2 correlated well from no-till to fall plow, with simple product moment correlation coefficients of 0.77 and 0.73, respectively. For PI, SKI, and PSKI, the coefficients were 0.29, 0.53, and 0.41, respectively. The rank correlation coefficients were similar to the product moment correlation coefficients.

The correlations of vigor traits in fall plow with agronomic traits in no-till, and vice versa, were calculated to investigate whether

Table 63. Correlations between expression of agronomic traits in no-till versus expression in conventional tillage, using entry-tillage means. Simple product moment correlation coefficients are listed. The coefficients on the diagonal to the right of the slash mark are Spearman rank correlation coefficients.

No-till traits	Fall plow traits			
	GPMS	GPMSA	WPP	M
	g/m^2	g/m^2	g	%
GPMS	0.66**/0.59**	0.64**	0.10	0.08
GPMSA	0.58**	0.61**/0.54**	0.27**	0.08
WPP	0.36**	0.42**	0.66**/0.71**	-0.07
M	0.02	0.06	0.17	0.82**/0.82**
PSL	-0.26**	-0.28**	-0.38**	0.08
PRL	0.01	0.03	-0.04	0.46**
PDE	0.07	0.06	-0.09	0.08
FST	0.20	0.11	-0.61**	0.20*
SG	0.16	0.19	0.24*	0.44**
PHT	0.03	0.02	-0.24*	0.22*
EHT	0.00	0.01	-0.12	0.25*
PFI	0.59**	0.62**	0.32**	0.01

*,**Significant at the 5% and 1% level of probability, respectively.

Fall plow traits			
PSL	PRL	PDE	FST
%	%	%	#/plot
-0.14	0.04	0.10	0.23*
-0.17	0.04	0.11	0.04
-0.41**	-0.21*	0.12	-0.54**
-0.17	0.30**	-0.16	-0.20*
0.82**/0.76**	0.16	-0.19	0.34**
0.04	0.67**/0.63**	-0.07	0.06
0.00	0.17	0.01/0.07	0.18
0.42**	0.31**	-0.07	0.86**/0.74**
-0.27**	0.42**	0.01	-0.17
0.28**	0.39**	-0.14	0.29**
0.20*	0.37**	-0.21*	0.12
-0.31**	-0.02	0.15	-0.02

Table 63. (Continued)

No-till traits	Fall plow traits			
	SG	PHT	EHT	PFI
	1-9	cm	cm	
GPMS	0.24*	0.04	-0.03	0.61**
GPMSA	0.26**	0.06	-0.02	0.59**
WPP	0.13	-0.27**	-0.18	0.48**
M	0.39**	0.11	0.24*	0.03
PSL	-0.14	0.48**	0.41**	-0.41**
PRL	0.46**	0.25*	0.37**	-0.04
PDE	-0.04	0.17	0.19	0.04
FST	0.08	0.43**	0.25*	0.01
SG	0.87**/0.82**	-0.02	0.18	0.18
PHT	0.09	0.90**/0.86**	0.72**	-0.06
EHT	0.19	0.66**	0.84**/0.83**	-0.06
PFI	0.24*	-0.05	-0.12	0.63**/0.56**

Table 64. Experiment 2 correlations between expression of early vigor traits in no-till versus expression in conventional tillage, using entry-tillage means. Simple product moment correlation coefficients are listed. The coefficients on the diagonal to the right of the slash mark are Spearmean rank correlation coefficients

	Fall plow traits				
No-till traits	PEM	EV	EMI	EPHT	BMPP
	%	1-9	days	cm	cm
PEM	0.92**/0.85**	0.72**	0.38**	-0.67**	0.20*
EV	0.75**	0.77**/0.79**	0.31**	-0.52**	0.23*
EMI	-0.74**	-0.60**	-0.22*/-0.27**	0.71**	-0.01
EPHT	-0.17	0.09	0.04	0.53**/0.58**	0.45**
BMPP	0.77**	0.73**	0.38**	-0.34**	0.43**/0.35**

*,**Significant at the 5% and 1% level of probability, respectively.

Table 65. Experiment 2 correlations between expression of pollen shedding and silking traits in no-till versus expression in conventional tillage, using entry-tillage means. Simple product moment correlation coefficients are listed. The coefficients on the diagonal to the right of the slash mark are Spearman rank correlation coefficients

	Fall plow traits				
No-till traits	PS2	SK2	PI	SKI	PSKI
	days	days	days	days	days
PS2	0.77**/0.75**	0.72**	0.32**	0.12	-0.10
SK2	0.72**	0.73**/0.72**	0.35**	0.16	0.04
PI	0.08	0.08	0.29**/0.30**	0.39**	-0.01
SKI	-0.23**	-0.15	0.39**	0.53**/0.55**	0.21*
PSKI	-0.03	0.14	0.11	0.15	0.41**/0.41**

*,**Significant at the 5% and 1% level of probability, respectively.

favorable or unfavorable associations were present. Table 66a lists the correlations of no-till agronomic characters with fall plow early vigor traits, and Table 66b lists the correlations between fall plow agronomic traits and no-till vigor traits. The vigor traits from fall plow were all significantly correlated with FST, although the correlation between EMI and FST was in the undesirable direction. The fall plow early vigor trait with the most favorable no-till associations appeared to be BMPP. For no-till early vigor traits, the most favorable associations with fall plow agronomic characters were noted for EPHT and BMPP. EPHT had significant positive correlations with GPMS, FST, and PHT. Most other correlations of the agronomic traits with EPHT and BMPP were in the favorable direction, if not significant.

Selection of lines

Lines were selected using GPMS, GPMSA, and two index selection procedures. Selection for each criterion will be discussed separately. Selection of lines was done within sets, with equal numbers selected within each set, as was done for Experiment 1.

When a 10% selection intensity was used with GPMS as the selection criterion, 4 of the 10 lines selected for each tillage system were in common (Table 67). For a 20% selection intensity, 12 of the 20 lines were in common. The mean of the fall plow selections in the fall plow system was 532 g/m^2 for the 10% selection intensity, and 513 g/m^2 for the 20% selection intensity (Table 68). The group selected using a 10% selection intensity for GPMS in no-till had a mean grain yield of 492 g/m^2 in fall plow, and the corresponding 20% selection intensity

Table 66. Experiment 2 correlations of (a) expression of agronomic traits in no-till with expression of early vigor traits in fall plow, and (b) expression of agronomic traits in fall plow with early vigor traits in no-till. Simple product moment correlation coefficients are listed, which were calculated using entry-tillage means

No-till traits	Fall plow traits				
	PEM	EV	EMI	EPHT	BMPP
	%	1-9	days	cm	cm
(a) No-till agronomic traits with fall plow early vigor traits					
GPMS	0.14	0.25*	0.29**	0.16	0.35**
GPMSA	0.02	0.14	0.12	0.13	0.20*
WPP	-0.59**	-0.36**	-0.24*	0.55**	0.03
M	-0.18	-0.24*	-0.07	0.04	-0.17
PSL	0.40**	0.22*	0.12	-0.50**	-0.15
PRL	0.04	0.01	0.06	-0.15	-0.11
PDE	0.19	0.15	0.02	-0.09	0.09
FST	0.86**	0.66**	0.49**	-0.62**	0.21*
SG	-0.20*	-0.23*	-0.06	0.08	-0.12
PHT	0.36**	0.29**	0.18	-0.31**	0.01
EHT	0.08	-0.02	0.11	-0.09	-0.05
PFI	-0.05	0.11	0.09	0.22*	0.23*
Fall plow traits	No-till traits				
(b) Fall plow agronomic traits with no-till vigor traits					
GPMS	0.13	0.14	0.00	0.18	0.21*
GPMSA	0.09	0.11	0.01	0.13	0.15
WPP	-0.53**	-0.42**	0.41**	0.07	-0.47**
M	0.23*	0.14	-0.12	-0.28*	0.06
PSL	0.43**	0.41**	-0.40**	-0.18	0.30**
PRL	0.37**	0.29**	-0.41**	-0.28**	0.18
PDE	-0.07	-0.06	0.09	0.12	0.00
FST	0.77**	0.63**	-0.59**	-0.05	0.69**
SG	0.08	-0.04	-0.06	-0.25*	-0.09
PHT	0.48**	0.41**	-0.51**	-0.14	0.36**
EHT	0.26**	0.13	-0.28**	-0.19	0.12
PFI	-0.02	0.01	0.10	0.18	0.07

*,**Significant at the 5% and 1% level of probability, respectively.

Table 67. Entry numbers of genotypes selected in no-till (NT) and fall plow (FP), with four different selection criteria, for Experiment 2

Selection		Selection criterion							
		GPMS		GPMSA		SHI		PFI	
Set	Rank	NT	FP	NT	FP	NT	FP	NT	FP
		g/m^2		g/m^2					
1	1	17	15	12	15	12	19	12	3
	2	11	11	3	16	3	11	3	16
	3	20	9	17	11	17	15	18	12
	4	12	12	18	12	18	18	17	15
2	1	22	35	27	35	22	31	31	31
	2	24	22	22	34	36	35	27	34
	3	25	34	26	30	34	40	36	35
	4	39	39	25	37	25	34	40	38
3	1	54	59	54	59	54	51	54	41
	2	51	47	51	47	51	58	58	58
	3	47	51	47	51	47	47	41	59
	4	58	58	58	58	58	59	47	42
4	1	77	80	77	80	77	77	77	77
	2	68	68	68	68	80	80	69	69
	3	80	64	80	64	68	72	68	80
	4	64	77	64	77	69	67	80	72
5	1	98	98	85	98	98	98	91	98
	2	85	84	98	84	91	89	98	84
	3	97	89	97	89	85	84	97	89
	4	92	93	92	93	97	81	89	87
# in common:									
10% selection		4/10		2/10		5/10		6/10	
20% selection		12/20		9/20		8/20		10/20	

group had a mean of 487 g/m^2 in fall plow.

Table 68. Mean fall plow grain yields of genotypes selected in no-till (NT) and fall plow (FP), based on GPMS and GPMSA, for Experiment 2

Selection criterion	Selection intensity	FP selection in FP	NT selection in FP	Difference
		g/m^2	g/m^2	g/m^2
GPMS	10%	532	492	40*
	20%	513	487	26*
GPMSA	10%	528	493	35*
	20%	510	481	29**

*,**A significant difference at the 5% and 1% level of probability, based on an LSD comparison.

The difference between means for the two 10% selection intensity groups was significant at the 5% level. The difference between the 20% selection intensity groups was also significant at the 5% level. Performance of these selection groups in no-till is listed in Table 69. The difference between the 10% selection intensity groups from each tillage system, evaluated in no-till, was 31 g/m^2, which was not significant at the 5% level. The difference for the 20% selection intensity groups was 22 g/m^2, which also was not a significant difference at the 5% level.

The same selection procedure was followed using GPMSA as the selection criterion. The entries selected in each set are listed in Table 67. For the 10% selection intensity, 2 of the 10 selections were

Table 69. Mean no-till grain yields of genotypes selected in no-till (NT) and fall plow (FP), based on GPMS and GPMSA, for Experiment 2

Selection criterion	Selection intensity	NT selection in NT	FP selection in NT	Difference
		g/m^2	g/m^2	g/m^2
GPMS	10%	427	396	31
	20%	416	394	22
GPMSA	10%	427	382	45**
	20%	415	388	27**

**A significant difference at the 1% level of probability, based on an LSD comparison.

common to both groups, and for the 20% selection intensity, 9 out of 20 of the selections were common to both groups. The 10% fall plow selection group mean for GPMSA in fall plow was 528 g/m^2, and the corresponding no-till group mean grain yield in fall plow was 493 g/m^2 (Table 68). The difference between these groups (35 g/m^2), was significant at the 5% level. The 20% selection group means for GPMSA in fall plow differed by 29 g/m^2, which was a significant difference at the 1% level. Means for GPMSA in no-till for the 10% selection intensity groups differed by 45 g/m^2, and for the 20% selection groups, the difference was 27 g/m^2. These differences were both significant at the 1% level, as compared by an LSD.

It was recognized that the differences found by comparing the groups in this fashion did not represent genetic differences, because selection and evaluation used the same data for one of the two groups being compared. Rather, they represented differences in selection differential which resulted when selection for a particular tillage system was done in the alternate tillage system. To estimate genetic differences required selection with one set of data, and evaluation with different data. As for Experiment 1, this was done by selecting with 1981 data and evaluating with 1982 data, and vice versa. Since only two of the five sets of genotypes were tested in both years, the procedure could be used only with those two sets.

Table 70 indicates the results for selection in one year, and evaluation in the alternate year. The GPMSA grain yield trait was used for selection and evaluation, as it had the best correlations between the two years. Variable results were obtained, with no consistent trend. When selections were made in 1981 and evaluation was done in 1982, the fall plow selections were no better than the no-till selections for grain yield in fall plow. No-till selections were 25 g/m^2 better than the fall plow selections when evaluated in no-till, but only 7 g/m^2 above the no-till experimental mean for 1982. For selection in 1982 and evaluation in 1981, the fall plow selections yielded 30 g/m^2 better than the no-till selections in the fall plow plow, and 19 g/m^2 better in the no-till plots. The performance for grain yield of the no-till selections made in 1982 as evaluated in 1981 were no better than the no-till experimental mean in 1981. For BS13(SCT)C6, selection for improved no-till grain yield performance was ineffective, as tested by the above procedure.

The same index selection methods were used for selection of lines

Table 70. Grain yield of groups selected in one year and evaluated in the alternate year, for Experiment 2. Selection was based on GPMSA in no-till and fall plow, with a 10% selection intensity

Selection group and tillage system	Selection in 1981, evaluation in 1982		Selection in 1982, evaluation in 1981	
	1981	1982	1982	1981
	g/m^2	g/m^2	g/m^2	g/m^2
FP selection, in FP	543	468	507	493
NT selection, in FL	494	472	467	463
Advantage	49	−4	40	30
NT selection, in NT	419	358	421	343
FP selection, in NT	365	333	376	362
Advantage	54	25	45	-19
FP mean	458	440	440	458
NT mean	346	351	351	346

as in Experiment 1. A Smith-Hazel index (SHI) procedure with nonstandardized variables was used, and a performance index (PFI) using heritabilities as b-values and nonstandardized variables was used. The entries selected by each index selection method are listed in Table 67.

Of the 20 lines selected using SHI, 8 were in common to both tillage selection groups, and 12 were unique to each group (Table 67). With a 20% selection intensity, the means for the FP selections for GPMSA, M, PSL, PRL, and BMPP were 500 g/m^2, 26.8%, 19.8%, 6.0%, and 196 cm, respectively (Table 71). The means in fall plow for the no-till SHI selections for the same five traits were 482 g/m^2, 26.6%, 20.1%, 5.9%, and 189 cm, respectively. The differences between these two selection groups, in fall plow, were relatively minor. With selection for GPMSA alone, the mean of the FP selections was 510 g/m^2 (Table 68). The means of the group selected in no-till by SHI, grown in no-till, were 411 g/m^2, 25.4%, 13.8%, 1.6%, and 150 cm, for the traits GPMSA, M, PSL, PRL, and BMPP, respectively. The FP SHI selections, evaluated in no-till, had means of 376 g/m^2, 26.6%, 15.5%, 1.4%, and 151 cm for the same respective traits. When selection for GPMSA alone was practiced, the mean of the group selected using a 20% selection intensity in no-till was 415 g/m^2 (Table 69).

When PFI was used as the selection criterion, 10 out of the 20 lines selected for each tillage system were in common to the two groups (Table 67). Means in fall plow for the group selected in fall plow were 497 g/m^2, 26.2%, 16.1%. 7.3%, and 187 cm for GPMSA, M, PSL, PRL, and BMPP, respectively (Table 71). The means in fall plow for the group

Table 71. Means for five traits of genotypes selected using two different index selection methods, for each tillage system, in Experiment 2. A 20% selection intensity was applied

Selection criterion	Selection group and tillage system	GPMSA	M	PSL	PRL	BMPP
		Traits				
		g/m^2	%	%	%	cm
Smith-Hazel index (SHI)	FP selection in FP	500	26.8	19.8	6.0	196
	NT selection in FP	482	26.2	20.1	5.9	189
	Difference	18	0.2	-0.3	0.1	7
	NT selection in NT	411	25.4	13.8	1.6	150
	FP selection in NT	376	26.6	15.5	1.4	151
	Difference	35	-1.2	-1.7	0.2	-1
Performance index (PFI)	FP selection in FP	497	26.2	16.1	7.3	187
	NT selection in FP	477	26.5	15.9	8.2	191
	Difference	20	-0.3	0.2	-0.9	-4
	NT selection in NT	397	26.3	11.1	2.3	150
	FP selection in NT	371	26.5	13.7	1.6	144
	Difference	26	-0.2	-2.6	0.7	6
Fall plow mean:		444	26.3	23.6	6.0	183
No-till mean:		349	26.5	19.0	1.7	140

selected in no-till for the same traits were, respectively, 477 g/m^2, 26.5%, 15.9%, 8.2%, and 191 cm. None of the differences, except for GPMSA, were large. The means in no-till for the group selected in no-till, were 397 g/m^2, 26.3%, 11.1%, 2.3%, and 150 cm for the traits GPMSA, M, PSL, PRL, and BMPP, respectively. The means in no-till for the group selected in fall plow were 371 g/m^2, 26.5%, 13.7%, 1.6%, and 144 cm for the same traits, respectively. The difference between the two groups was 26 g/m^2 for grain yield, but no other difference were large.

The use of multiple trait index selection, in general, appeared to put the major emphasis on grain yield, while keeping grain moisture constant. It caused small reductions in stalk lodging, and small improvements in early vigor. Differences for traits other than grain yield were minor, when genotypes selected in one tillage system were compared, in a common tillage system, to genotypes selected in the alternate tillage system.

Experiment 3: Commercial Hybrids

Results were divided into an analysis of variance section, a section on correlations among traits, and a section on selection of hybrids.

Analysis of variance

The analysis of variance section will be discussed in five subsections: (1) early vigor traits, (2) pollen shedding and silking traits, (3) mature plant traits, (4) harvest traits, and (5) within plot variability traits. The subplot analysis will not be discussed. Hybrids were randomly assigned to sets, and sets were incomplete blocks.

Hybrids were fixed effects for Experiment 3. Therefore, variance components and heritability estimates were not calculated. Repeatability estimates, which correspond to heritability estimates in calculation but not interpretation, were calculated to indicate the relative amount of genotypic variation expressed for a particular trait. The repeatability estimates also provided a method to examine differences between tillage systems.

Early vigor traits The five early vigor traits considered included percentage emergence (PEM), visual early vigor (EV), rate of emergence index (EMI), early plant height (EPHT), and a biomass per plot rating (BMPP). For the combined anova over tillage systems, PEM, EV, EPHT, and BMPP had significant variation due to environments (Table 72). All of the early vigor traits had significant tillage by environment (T x E) interactions, but none had a significant tillage source. As for Experiments 1 and 2, the largest environmental difference for early vigor was the difference between 1981 and 1982 (Table 73). In 1981, no-till plots had marked reductions in early vigor relative to fall plow, for all five of the early vigor traits, and in both locations. In 1982, no-till early vigor was reduced relative to fall plow early vigor, but the magnitude of the differences was much smaller than in 1981.

All five early vigor traits had significant genotypic variation in the combined anova over tillage systems (Table 72). PEM and BMPP had

Table 72. The combined analysis of variance, over environments and tillage systems, for early vigor traits in Experiment 3

Source of variation	df	PEM	EV	EMI	EPHT	BMPP
		Trait				
		%	1-9	days	cm	cm
Environments (E)	3	30918.87**	175.35*	57.22	24009.97**	1173359**
Replications (R)/E	4	782.82	12.62	75.29	499.01	34856
Tillage (T)	1	23425.69	685.13	5265.54	39987.44	4128131
T x E	3	9209.34*	178.80**	1395.60**	7321.65*	825382*
Error a (T x R/E)	4	574.63	6.48	5.91	797.69	69440
Sets (S)	2	1256.12**	6.01	30.70	175.98**	33742
S x E	6	69.88	2.60	19.63	62.79	3351
S x T	2	5.37	0.18	1.83	9.38	2060
S x T x E	6	75.89	4.04	13.44	67.51	4793
Error b (Pooled error)	16	158.16	2.12	12.04	107.35	11971
Genotypes (G)/S	57	456.44**	3.65**	10.47**	72.33**	9550**
G x E/S	171	94.75**	1.08	5.31	24.59	3104**
G x T/S	57	67.41	0.93	5.17	23.13	2617
G x T x E/S	171	92.56**	1.06	3.91	18.04	2527
Error c (Pooled error)	456	69.66	0.94	4.96	20.32	2236
Repeatability		0.79	0.70	0.49	0.66	0.67

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 73. Environment, tillage, and environment-tillage means for early vigor traits in Experiment 3

Type of mean		PEM	EV	EMI	EPHT	BMPP
		%	1-9	days	cm	cm
Experiment mean, overall		81.9	5.7	19.0	30.8	240
Tillage means:	No-till (NT)	77.0	4.9	21.3	24.4	175
	Fall plow (FP)	86.8	6.6	16.6	37.3	306
Year means:	1981	72.2	5.3	19.2	39.3	297
	1982	91.5	6.2	18.8	22.4	185
Location means:	Nashua	81.0	6.4	19.1	31.0	235
	Ames	82.8	5.1	19.0	30.7	248
Environment means:	Nashua 1981 (1)	69.8	5.9	19.6	37.4	265
	Ames 1981 (2)	74.6	4.7	18.8	41.1	329
	Nashua 1982 (3)	92.2	6.8	18.5	24.5	204
	Ames 1982 (4)	90.9	5.5	19.1	20.2	166
Environment-tillage means:	1-NT	66.1	4.5	24.0	26.6	177
	1-FP	73.6	7.2	15.1	48.1	354
	2-NT	60.6	3.0	23.3	29.4	191
	2-FP	88.6	6.5	14.3	52.8	468
	3-NT	91.3	6.9	18.7	22.9	188
	3-FP	93.0	6.7	18.2	26.2	219
	4-NT	89.8	5.2	19.3	18.5	150
	4-FP	92.0	5.9	18.8	21.9	182

significant G x E/S interactions, and PEM also had a significant G x T x E/S interaction. Repeatability estimates ranged from 49% for EMI to 79% for PEM.

Combined anovas within each tillage system for the early vigor traits are listed in Table 74. In the no-till combined anova, PEM, EV, and EMI had significant environmental variation, and all five vigor traits had significant genotypic variation. PEM, EMI, EPHT, and BMPP had significant environment sources of variation in the combined anova for fall plow. All early vigor traits except EMI had significant genotypic variation in fall plow, and PEM had a significant genotype by environment interaction. Repeatability estimates for PEM, EPHT, and BMPP were somewhat larger in fall plow than no-till, and the repeatability estimates for EV were similar for the two tillage systems. A repeatability estimate for EMI was not calculated for fall plow, due to the nonsignificance of the G/S source in fall plow.

Pollen shedding and silking traits The environment source of variation was significant for 50% silking date (SK2), pollen interval (PI), and the pollen-shed-to-silking interval (PSKI) in the combined anova over tillage systems (Table 75). The 50% pollen shedding date (PS2) and SK2 had significant tillage sources, and silking interval (SKI) had a significant tillage by environment interaction. PS2 and SK2 means were 3.9 and 4.0 days later in no-till than fall plow, respectively (Table 76). PI and SKI means tended to be larger in no-till than fall plow at Nashua in 1981. Differences were minor for the other two environments. No trend in tillage induced effects on mean

Table 74. The combined analysis of variance for early vigor traits, with (a) the no-till system, and (b) the fall plow system, in Experiment 3

Source of variation	df	PEM	EV	EMI	EPHT	BMPP
		%	1-9	days	cm	cm
(a) Combined anova for no-till						
Environments (E)	3	30333.74**	316.92**	855.46*	2672.51	33935
Replications (R)/E	4	1319.75	11.09	57.91	891.82	85216
Sets (S)	2	671.16	3.16	21.80	59.75	10183
S x E	6	89.53	4.33	29.23	51.83	5698
Error a (S x R/E)	8	206.46	1.67	23.48	139.74	11902
Genotypes (G)/S	57	340.95**	2.57**	13.15**	31.82**	5255**
G x E/S	171	142.23	1.18	7.18	18.57	2932
Error b (residual)	228	112.06	1.08	7.55	18.49	2314
Repeatability		0.58	0.54	0.43	0.41	0.44
(b) Combined anova for fall plow						
Environments (E)	3	9794.47**	37.24	597.36**	28659.11**	2054806**
Replications (R)/E	4	37.59	8.01	23.30	402.63	19081
Sets (S)	2	590.32	3.03	10.73	125.61	25619
S x E	6	56.24	2.30	3.85**	78.45	2446
Error a (S x R/E)	8	107.82	2.86	0.59	74.96	11983
Genotypes (G)/S	57	182.91**	2.01**	2.49	63.64**	6913**
G x E/S	171	45.08**	0.96	2.03	24.05	2699
Error b (residual)	228	27.28	0.79	2.36	22.15	2159
Repeatability		0.75	0.52	---[a]	0.62	0.61

[a]No repeatability estimate was calculated, due to the lack of significant genotypic variation.

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 75. The combined analysis of variance, over environments and tillage systems, for pollen shedding and silking traits in Experiment 3

Source of variation	df	PS2	SK2	PI	SKI	PSKI
		Trait				
		days	days	days	days	days
Environments (E)	2	134.69	706.93*	321.10**	225.01	1335.98*
Replications (R)/E	3	43.95	32.26	5.23	31.74	22.15
Tillage (T)	1	2717.91*	2860.00*	54.34	179.00	1.81
T x E	2	233.44	207.34	29.67	147.57*	39.21
Error a (T x R/E)	3	112.25	192.42	7.19	15.35	19.98
Sets (S)	2	120.43**	59.02*	1.89	5.28	10.84*
S x E	4	22.96	21.26	8.59*	6.26	2.66
S x T	2	17.57	5.06	10.93*	3.54	4.66
S x T x E	4	4.14	5.77	1.53	4.84	1.90
Error b (Pooled error)	12	18.13	15.23	1.92	9.41	2.44
Genotypes (G)/S	57	57.17**	46.35**	4.37*	4.16	6.00**
G x E/S	113	7.99*	7.50	2.77	3.73	2.78
G x T/S	57	4.83	7.08	2.63	3.56	4.04**
G x T x E/S	113	3.79	4.07	3.61	4.43	1.95
Error c (Pooled error)	340	6.10	6.72	2.80	3.25	2.44
Repeatability		0.86	0.83	0.36	---[a]	0.54

[a]No repeatability estimate was calculated, due to the lack of significant genotypic variation.

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 76. Environment, tillage, and environment-tillage means for pollen shedding and silking traits in Experiment 3

Type of mean			Trait				
			PS2	SK2	PI	SKI	PSKI
			days	days	days	days	days
Experiment mean, overall			88.0	88.7	4.3	4.4	0.7
Tillage means:	No-till (NT)		89.9	90.7	4.6	4.9	0.8
	Fall plow (FP)		86.0	86.7	4.1	3.9	0.7
Year means:	1981		88.2	87.9	4.7	4.8	0.9
	1982		87.7	88.2	3.7	3.6	0.5
Location means:	Nashua		88.9	85.2	5.7	5.5	-1.5
	Ames		87.6	89.4	3.7	3.8	1.9
Environment means:	Nashua 1981 (1)		88.9	87.3	5.7	5.5	-1.5
	Ames 1981 (2)		87.5	90.6	3.6	4.0	3.2
	Nashua 1982 (3)		--[a]	--	--	--	--
	Ames 1982 (4)		87.7	88.2	3.7	3.6	0.5
Environment-tillage means:		1-NT	91.2	90.1	6.3	6.9	-1.1
		1-FP	86.5	84.6	5.1	4.1	-1.9
		2-NT	90.1	92.9	3.9	4.0	2.8
		2-FP	84.8	88.4	3.3	3.9	3.6
		3-NT	--	--	--	--	--
		3-FP	--	--	--	--	--
		4-NT	88.5	89.2	3.6	3.7	0.7
		4-FP	86.9	87.2	3.8	3.6	0.4

[a]Pollen shedding and silking traits were measured in only three environments.

PSKI were noted.

In the subsubplot analysis for the combined anova over tillage systems (Table 75), PS2, SK2, PI, and PSKI had significant genotypic variation, PS2 had a significant genotype by environment interaction, and PSKI had a significant G x T x E/S interaction. The repeatability estimate for PI was small (36%), the estimate for PSKI was intermediate (54%), and for PS2 and SK2 the estimates were relatively high (86% and 83%, respectively).

PI, SKI, and PSKI had significant environmental variation in the combined anova within no-till (Table 77a). Only PS2 and SK2 had significant genotypic variation. In the fall plow anova, PI and PSKI had significant environment sources (Table 77b). All traits except SKI had significant genotypic variation in the fall plow anova, and SKI had a significant genotype by environment interaction. The two traits with repeatability estimates for both tillage systems were PS2 and SK2. The PS2 repeatability estimate was somewhat greater for fall plow than no-till (87% vs 76%, respectively), but the SK2 estimates were similar for both tillage systems (72% vs 76%, respectively).

Mature plant traits   Plant height (PHT), ear height (EHT), and stay green (SG) had significant variation due to environments in the combined anova over tillage systems (Table 78). EHT had a significant tillage source, and SG had a significant T x E interaction. PHT and EHT means were lower in no-till than fall plow in every environment (Table 79). The mean PHT in no-till was 6 cm shorter than the mean PHT in fall plow (192 vs 198 cm, respectively), and the mean EHT in no-till

Table 77. The combined analysis of variance for the pollen shedding and silking traits with (a) the no-till system, and (b) the fall plow system, in Experiment 3

Source of variation	df	PS2	SK2	PI	SKI	PSKI
		days	days	days	days	days
(a) Combined anova for no-till						
Environments (E)	2	228.17	445.44	251.47*	366.09*	461.27**
Replications (R)/E	3	122.57	113.65	10.87	19.71	1.13
Sets (S)	2	43.82	27.34	3.36	6.69	2.22
S x E	4	16.35	20.87	4.42	10.03	2.65
Error a (S x R/E)	6	18.67	18.24	2.73	14.62	1.12
Genotypes (G)/S	57	33.19**	35.18**	3.20	5.44	2.69
G x E/S	113	7.90	8.05	3.70	4.68	1.85
Error b (residual)	170	6.94	8.27	3.32	4.35	2.29
Repeatability		0.76	0.76	---[a]	---	---
(b) Combined anova for fall plow						
Environments (E)	2	139.98	468.83	99.30**	6.49	913.92*
Replications (R)/E	3	33.66	111.04	1.56	27.39	40.99
Sets (S)	2	94.18*	36.74	9.46	2.13	13.28
S x E	4	10.75	6.16	5.69*	1.08	1.90
Error a (S x R/E)	6	17.86	13.38	1.11	4.49	4.05
Genotypes (G)/S	57	28.81**	18.25**	3.80**	2.28	7.35**
G x E/S	113	3.88	3.51	2.67	3.48**	2.88
Error b (residual)	170	5.25	5.17	2.28	2.14	2.58
Repeatability		0.87	0.72	0.30	---	0.61

[a]No repeatability estimate was calculated, due to the lack of significant genotypic variation.

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 78. The combined analysis of variance, over environments and tillage systems, for mature plant traits in Experiment 3

Source of variation	df	Trait		
		PHT	EHT	SG
		cm	cm	1-9
Environments (E)	3	28387**	8290**	287.52**
Replications (R)/E	4	754	322	9.27
Tillage (T)	1	7500	13180*	0.23
T x E	3	517	302	4.81*
Error a (T x R/E)	4	4409	1529	1.25
Sets (S)	2	376	36	47.75**
S x E	6	177*	71	2.53
S x T	2	81	131	1.75
S x T x E	6	90	42	0.70
Error b (Pooled error)	16	47	55	2.29
Genotypes (G)/S	57	2897**	2594**	13.26**
G x E/S	171	164**	57**	1.69**
G x T/S	57	74	45**	1.20
G x T x E/S	171	60*	28	1.03*
Error c (Pooled error)	456	47	25	0.81
Repeatability		0.94	0.97	0.87

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 79. Environment, tillage, and environment-tillage means for mature plant traits in Experiment 3

Type of mean		PHT	EHT	SG
		cm	cm	1-9
Experiment mean, overall		195	87	3.6
Tillage means:	No-till (NT)	192	83	3.5
	Fall plow (FP)	198	91	3.6
Year means:	1981	192	86	4.1
	1982	198	88	3.0
Location means:	Nashua	204	91	4.2
	Ames	186	82	2.9
Environment means:	Nashua 1981 (1)	202	89	4.5
	Ames 1981 (2)	182	84	3.8
	Nashua 1982 (3)	206	94	4.0
	Ames 1982 (4)	189	81	2.0
Environment-tillage means:	1-NT	199	85	4.7
	1-FP	205	92	4.3
	2-NT	182	79	3.7
	2-FP	183	89	3.9
	3-NT	201	91	3.9
	3-FP	210	98	4.1
	4-NT	186	78	1.9
	4-FP	192	84	2.0

was 8 cm shorter than the mean EHT in fall plow (83 vs 91 cm, respectively). The effect of tillage on SG was variable across environments. All three of the traits had significant genotype and genotype by environment sources of variation in the combined anova over tillage systems (Table 78). EHT had a significant G x T/S source, and the G x T x E/S interaction was significant for PHT and SG. Repeatability estimates over tillage systems for PHT, EHT, and SG were high (94, 97, and 87%, respectively).

For the combined anova within no-till (Table 80a), PHT had a significant E source, all three traits had significant genotypic variation, and PHT and SG had a significant genotype by environment interaction. In the fall plow anova (Table 80b), EHT and SG had a significant E source, and all three traits had significant genotype and genotype by environment sources of variation. Repeatability estimates for PHT, EHT, and SG were 96%, 97%, and 77% in no-till, and 88%, 96%, and 86% in fall plow, respectively.

Harvest traits The three grain yield traits used were grams per square meter (GPMS), grain yield adjusted for stand (GPMSA), and grain weight per plant (WPP). All three had significant environment sources of variation in the combined anova over tillage systems and environments (Table 81). Tillage and T x E interactions were not statistically significant. The GPMS mean was reduced around 8% in no-till, relative to the fall plow mean (715 vs 780 g/m^2, respectively) (Table 82). The mean WPP was reduced only around 3%. The means could indicate much of the reduction in GPMS was due to reduced final stand

Table 80. The combined analysis of variance for mature plant traits, within (a) the no-till system, and (b) the fall plow system, in Experiment 3

Source of variation	df	Trait		
		PHT	EHT	SG
		cm	cm	1-9
(a) Combined anova for no-till				
Environments (E)	3	11081*	4446	159.99
Replications (R)/E	4	1146	1289	5.85
Sets (S)	2	363**	64	20.66
S x E	6	101	70	0.64
Error a (S x R/E)	8	38	58	1.57
Genotypes (G)/S	57	1589**	1227**	7.62**
G x E/S	171	62**	33	1.74**
Error b (residual)	228	38	28	0.98
Repeatability		0.96	0.97	0.77
(b) Combined anova for fall plow				
Environments (E)	3	17822	4145*	132.34**
Replications (R)/E	4	4017	562	4.67
Sets (S)	2	94	104*	28.84**
S x E	6	166*	43	2.60
Error a (S x R/E)	8	55	22	3.00
Genotypes (G)/S	57	1383**	1412**	6.85**
G x E/S	171	162**	52**	0.98**
Error b (residual)	228	55	22	0.64
Repeatability		0.88	0.96	0.86

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 81. The combined analysis of variance, over environments and tillage systems, for harvest traits in Experiment 3

Source of variation	df	Trait GPMS	GPMSA	WPP
		g/m^2	g/m^2	g
Environments (E)	3	2280411*	2280326*	91103*
Replications (R)/E	4	148238	323483	11089
Tillage (T)	1	1019985	1019145	4184
T x E	3	123226	123320	23889
Error a (T x R/E)	4	506572	282292	9399
Sets (S)	2	10511	15826	1175
S x E	6	12457	12416	598
S x T	2	55792	66865	1690
S x T x E	6	51336**	54055*	1711*
Error b (Pooled error)	16	19013	16268	453
Genotypes (G)/S	57	121159**	112593**	3731**
G x E/S	171	25235**	20252**	701**
G x T/S	57	15434	13036	536
G x T x E/S	171	16210	12917	495
Error c (Pooled error)	456	14057	10987[a]	453
Repeatability		0.79	0.82	0.81

[a]GPMSA had 452 df for error c, as four degrees of freedom were used to make the correction for stand variability.

[b]No repeatability estimate was calculated, due to the lack of significant genotypic variation.

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Trait				
M	PSL	PRL	PDE	FST
%	%	%	%	#/plot
636.27	56212.83**	1279.37*	20.75	1158.54
89.72	214.51	82.55	4.43	177.50
92.87	40.50	436.80*	5.88	1404.09
114.12	312.74	249.81	8.93*	1302.60*
6.53	58.31	53.48	0.54	151.55
25.02*	1621.81	51.29	4.05**	61.79**
3.69	780.98**	57.56*	1.62	8.83
3.00	165.51	5.20	0.16	1.64
7.28	175.33**	2.95	0.97	3.15
6.42	15.58	20.29	0.64	9.59
30.35**	429.80*	25.95	0.80	38.55*
2.71	301.16**	23.03**	0.85**	27.07**
3.63	30.17	7.68	0.96	24.02
3.47	27.65	6.63	0.88**	19.91
3.17	38.29	9.67	0.64	17.85
0.90	0.30	--[b]	--	0.30

Table 82. Environment, tillage, and environment-tillage means for harvest traits in Experiment 3

Type of mean		GPMS	GPMSA	WPP	M	PSL	PRL	PDE	FST
		Trait							
		g/m^2	g/m^2	g	%	%	%	%	#/plot
Experiment mean, overall		747	747	140	20.7	10.0	1.4	0.3	45.0
Tillage means:	No-till (NT)	715	715	138	21.0	10.3	0.7	0.2	43.8
	Fall plow (FP)	780	780	142	20.4	9.8	2.1	0.4	46.2
Year means:	1981	767	767	149	21.8	2.0	0.4	0.4	43.3
	1982	728	728	131	19.6	18.1	2.4	0.2	46.8
Location means:	Nashua	821	821	153	21.2	17.4	2.8	0.1	45.2
	Ames	674	674	126	20.3	2.7	0.0	0.5	44.9
Environment means:	Nashua 1981 (1)	877	877	166	21.6	1.7	0.7	0.2	44.1
	Ames 1981 (2)	658	658	132	22.1	2.2	0.0	0.7	42.4
	Nashua 1982 (3)	766	766	139	20.9	33.0	4.8	0.0	46.2
	Ames 1982 (4)	690	690	122	18.4	3.3	0.0	0.3	47.4
Environment-tillage means:	1-NT	839	839	160	22.7	1.4	0.1	0.2	44.1
	1-FP	915	915	172	20.4	2.1	1.3	0.2	44.1
	2-NT	636	636	144	22.7	1.3	0.0	0.3	37.7
	2-FP	679	679	121	21.5	3.1	0.0	1.1	47.1
	3-NT	756	756	139	20.8	34.7	2.7	0.1	45.8
	3-FP	775	775	140	21.0	31.3	7.0	0.0	46.5
	4-NT	628	628	111	18.0	3.7	0.1	0.3	47.5
	4-FP	751	751	133	18.8	2.9	0.0	0.3	47.2

(FST). However, at Nashua in 1981 and Ames in 1982 the final stand means were nearly equal for the two tillage systems, yet grain yields were reduced 8% and 16%, respectively, in no-till relative to fall plow. The environment with the greatest difference in final stand between the two tillage systems (Nashua, 1981) had only a 6% reduction in the no-till GPMS mean, relative to fall plow. The three grain yield traits had significant genotype and genotype by environment sources of variation in the anova across tillage systems (Table 81). Repeatability estimates were near 80% for all three traits.

The environment, genotype, and genotype by environment sources were significant for GPMS, GPMSA, and WPP traits in no-till (Table 83a). Genotype and genotype by environment sources were significant for the three traits in the fall plow anova (Table 83b). Repeatability estimates for the three traits were similar and near 70-75% within each tillage system.

Percentage grain moisture (M) had significant genotypic variation in the combined anova over tillage systems (Table 81), but no other main plot or subsubplot source was significant. The mean M was 21.0% in no-till and 20.4% in fall plow (Table 82). In 1981, the no-till M mean was higher than fall plow in both locations, but in 1982 the reverse was true. The repeatability for M in the combined anova over tillage systems and environments was 90% (Table 81).

The E and G/S sources of variation were significant for M in the no-till combined anova, and G/S was the only significant source in the fall plow anova (Table 83). The repeatability was near 80% for both

Table 83. The combined analysis of variance for harvest traits, with (a) the no-till system, and (b) the fall plow system, in Experiment 3

		Trait		
Source of variation	df	GPMS	GPMSA	WPP
		g/m^2	g/m^2	g
(a) Combined anova for no-till				
Environments (E)	3	1232318*	1232328**	49468**
Replications (R)/E	4	103454	49078	1773
Sets (S)	2	48127	70179*	2844
S x E	6	38720	38430	1505*
Error a (S x R/E)	8	22517	16375	410
Genotypes (G)/S	57	66020**	58044**	2041**
G x E/S	171	20837**	14122**	536*
Error b (residual)	228	14248	8764[a]	410
Repeatability		0.68	0.76	0.74
(b) Combined anova for fall plow				
Environments (E)	3	1171319	1171319	65524
Replications (R)/E	4	551357	559698	18715
Sets (S)	2	18176	12512	21
S x E	6	25072	28041	804
Error a (S x R/E)	8	12480	16159	495
Genotypes (G)/S	57	70574**	67584**	2226**
G x E/S	171	20608**	19047**	660*
Error b (residual)	228	13886	13209[c]	495
Repeatability		0.71	0.72	0.70

[a]GPMSA had 225 df for error b in no-till, as 3 df were used to make the correction for stand variability.

[b]No repeatability estimate was calculated, due to the lack of significant genotypic variation.

[c]GPMSA had 227 df for error b in fall plow, as 1 df was used to make the correction for stand variability.

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Trait				
M	PSL	PRL	PDE	FST
%	%	%	%	#/plot
586.53*	31992.53**	204.72	1.82	2201.99*
48.73	67.41	118.98	1.26	268.06
6.43	1180.45	33.85	1.63	26.44
3.10	682.17**	25.04	0.82	7.59
7.53	22.96	15.69	0.58	12.27
19.11**	233.42	11.11	0.79	48.18**
3.56	166.93**	8.91	0.79*	34.36
3.99	35.94	8.31	0.58	27.90
0.81	---[b]	---	---	0.29
163.85	24533.00**	1324.49**	27.85*	259.15
47.53	205.41	17.05	3.71	60.99
21.60	606.24	22.63	2.58	36.98
7.87	274.14**	35.47	1.77**	4.39
5.02	7.62	18.70	0.41	6.92
14.86**	226.55	22.52	0.98	14.39
2.61	161.89**	20.74**	0.93*	12.63**
2.36	40.66	11.03	0.70	7.80
0.82	---	---	---	---

tillage systems.

Percentage stalk lodging (PSL) had significant genotype and genotype by environment sources of variation in the combined anova over tillage systems (Table 81). The E, T, and T x E sources were not significant. The repeatability estimate was low (30%). Percentage root lodging had a significant tillage and genotype by environment source in the combined anova over tillage systems. The G/S source was not significant; therefore, a repeatability estimate for PRL was not calculated. The mean PSL was 10.3% in no-till and 9.8% in fall plow (Table 82). For PRL, the no-till mean was 0.7% and the fall plow mean was 2.1%. The only environment with considerable lodging was Nashua in 1982. In that environment, the PSL mean was slightly larger in no-till than fall plow (34.7 vs 31.3%, respectively), and the PRL mean was larger in fall plow than no-till (7.0 vs 2.7%, respectively).

Neither PSL or PRL had significant genotypic variation (G/S) expressed in either of the combined anovas within a tillage system (Table 83). In no-till, PSL had a significant E source and G x E/S interaction, and none of the sources were significant for PRL. In fall plow, PSL and PRL both had a significant E source and G x E/S interaction. Due to the lack of significant genotypic variation, repeatability estimates were not calculated.

The amount of ear droppage observed for this experiment was minimal, as can be noted from the main plot means for percentage dropped ears (PDE) (Table 82). The data for PDE are listed in Tables 81, 82, and 83, but will not be discussed.

The T x E source of variation was significant in the main plot analysis for final stand (FST) in the combined anova over tillage systems and environments (Table 81). The no-till mean for FST was 2.4 plants/plot less than the FST mean for fall plow (43.8 vs 46.2 plants/plot, respectively) (Table 82). The only environment in which a large difference between tillage systems was observed for FST was Ames in 1981. The no-till FST mean was 37.7 plants/plot and the fall plow was 47.1 plants/plot. In the subsubplot analysis for the combined anova over tillage systems and environments (Table 81), the genotype and genotype by environment sources were significant. The G/S source was significant only at the 5% level, though, and the repeatability estimate was small (30%).

In the combined anova for no-till, the E and G/S sources were significant for FST (Table 83a). For fall plow, the genotype by environment interaction was significant but the G/S source was not significant (Table 83b). The repeatability estimate was 29% in no-till. No estimate was calculated for fall plow because significant genotypic variation was not present.

Within plot variability traits   Within plot variances were calculated using the within plot samples for PHT, EHT, and EPHT. From these variances, within plot standard deviations for the traits (PHTS, EHTS, and EPHTS, respectively), and within plot coefficients of variability (PHTCV, EHTCV, and EPHTCV, respectively) were calculated. The standard errors and coefficients of variability were examined in a combined analysis of variance over tillage systems and environments to determine whether an effect due to tillage on within plot variability could be observed. It was recognized, however, that the experiment was not designed to provide a strong test for the main plot effects. Means for main plot effects were calculated, to determine whether trends were present.

Five of the six within plot variability traits had significant environmental variation in the combined analysis of variance (Table 84). EHTS was the exception. Only EHTCV and EPHTCV had significant tillage effects, and none of the traits had significant T x E interactions.

The means for the within plot variability traits were greater in no-till than fall plow in 1981 for all traits but EPHTS (Table 85). The differences between the two tillage systems in 1982 was less uniform; the coefficients of variability were generally larger in no-till than fall plow, but there was no consistent trend for the within plot standard errors. Five of the six traits had slightly lower means in fall plow than in no-till.

<u>Summary for the analysis of variance section</u> Of the twenty-seven traits examined in a combined analysis, only 3 had a significant genotype by tillage interaction (PSKI, EHT, and EHTCV). Five traits had significant genotype by tillage by environment interactions (PEM, PHT, SG, PDE, and PHTCV). None of the harvest traits (except PDE) had a significant interaction between hybrids and tillage systems.

A significant tillage source of variation was observed for six traits (PS2, SK2, EHT, PRL, EHTCV, and EPHTCV). Nine traits had a significant tillage by environment (T x E) interaction (PEM, EV, EMI,

Table 84. The combined analysis of variance, over environments and tillage systems, for within plot variability traits in Experiment 3

Source of variation	df	PHTS	EHTS	EPHTS	PHTCV	EHTCV	EPHTCV
		Trait					
		cm	cm	cm			
Environments (E)	3	329.72*	64.93	1604.64**	103.23**	281.42*	3980.17*
Replications (R)/E	4	13.85	17.63	18.99	3.87	33.85	513.45
Tillage (T)	1	80.91	16.67	36.26	47.82	383.60**	9733.90**
T x E	3	70.65	26.66	15.70	16.96	63.94	1412.50
Error a (T x R/E)	4	13.77	21.75	21.00	9.86	16.70	265.62
Sets (S)	2	61.39	5.14	16.97	11.74	11.43	246.81
S x E	6	15.62	4.64	13.82	5.07	10.05	157.16
S x T	2	63.90	10.83	1.60	18.33	3.77	4.97
S x T x E	6	16.28	12.10	3.82	5.45	13.33	67.19
Error b (Pooled error)	16	24.59	15.12	5.46	6.80	19.02	129.32
Genotypes (G)/S	57	53.37**	32.68**	5.59	15.67**	100.44**	51.34
G x E/S	171	15.52*	9.43	4.55*	4.52**	14.76*	55.45
G x T/S	57	15.21	10.94	4.13	4.19	16.69*	46.53
G x T x E/S	171	14.68	9.01	3.85	4.08*	12.25	43.62
Error c (Pooled error)	456	12.18	8.13	3.64	3.26	11.64	48.78
Repeatability		0.71	0.71	---[a]	0.71	0.85	---

[a]No repeatability estimate was calculated, due to the lack of significant genotypic variation.

*,**Significant at the 5% and 1% level of probability, respectively, when tested by the F statistic.

Table 85. Environment, tillage, and environment-tillage means for within plot variability traits in Experiment 3

Type of mean		PHTS	EHTS	EPHTS	PHTCV	EHTCV	EPHTCV
		Trait					
		cm	cm	cm	%	%	%
Experiment mean, overall		11.0	10.0	5.6	5.7	11.9	18.7
Tillage means:	No-till (NT)	11.3	10.2	5.4	5.9	12.6	21.9
	Fall plow (FP)	10.8	9.9	5.8	5.5	11.3	15.5
Year means:	1981	11.7	10.3	7.9	6.1	12.3	22.4
	1982	10.4	9.8	3.4	5.4	11.7	15.9
Location means:	Nashua	11.1	10.1	5.3	5.5	11.4	17.4
	Ames	11.0	10.0	6.0	6.0	12.5	20.8
Environment means:	Nashua 1981 (1)	12.5	10.7	7.4	6.2	12.4	21.6
	Ames 1981 (2)	10.9	9.8	8.3	6.0	12.1	23.1
	Nashua 1982 (3)	9.7	9.5	3.2	4.8	10.4	13.2
	Ames 1982 (4)	11.1	10.1	3.6	5.9	12.9	18.5
Environment-tillage means:	1-NT	13.5	11.3	7.0	6.8	13.5	26.4
	1-FP	11.6	10.1	7.8	5.7	11.2	16.7
	2-NT	11.1	10.0	7.9	6.2	13.1	29.3
	2-FP	10.6	9.7	8.6	5.9	11.1	16.8
	3-NT	9.3	9.4	3.4	4.7	10.6	14.8
	3-FP	10.1	9.6	3.0	4.9	10.2	11.6
	4-NT	11.4	10.0	3.4	6.2	13.1	19.5
	4-FP	10.7	10.2	3.8	5.6	12.7	17.6

BMPP, SKI, SG, PDE, and FST). All five of the early vigor traits had significant T x E interactions.

All but four of the traits examined had significant genotypic variation, and 17 of 27 had a significant genotype by environment interaction. The four traits without significant genotypic variation were SKI, PDE, EPHTS, and EPHTCV. PDE was the only one of these with a significant genotype by environment interaction.

Correlations among traits

As for Experiments 1 and 2, traits were divided into three groups: (1) agronomic traits (GPMS, GPMSA, WPP, M, PSL, PRL, PDE, FST, SG, PHT, EHT, and a performance index, PFI), (2) early vigor traits (PEM, EV, EMI, EPHT, and BMPP), and (3) pollen shedding and silking traits (PS2, SK2, PI, SKI, and PSKI).

It was recognized that the correlations among these fixed hybrids pertained only to the group of hybrid genotypes included in the study. However, the hybrids constituted a cross section of genotypes currently grown by farmers, and the associations within this group were of interest.

Correlations within each tillage system The simple correlations among agronomic characters within no-till and fall plow are listed in Table 86. The three yield traits (GPMS, GPMSA, and WPP) were closely correlated in no-till (0.85 to 0.97), and even more closely correlated in fall plow (0.95 to 0.99). Correlations of grain yield traits with other agronomic characters were similar in both tillage systems. Increased grain yield was associated with higher grain moisture at harvest, increased root lodging, larger stay green values, and taller

Table 86. Simple correlations among agronomic traits in Experiment 3, within tillage systems, using entry-tillage means. Coefficients above the diagonal are correlations in no-till, and below the diagonal are correlations in fall plow

	Trait				
Trait	GPMS	GPMSA	WPP	M	PSL
	g/m^2	g/m^2	g	%	%
GPMS		0.94**	0.85**	0.69**	-0.10
GPMSA	0.99**		0.97**	0.73**	-0.04
WPP	0.95**	0.97**		0.71**	-0.01
M	0.59**	0.60**	0.62**		-0.07
PSL	-0.22	-0.20	-0.20	-0.27*	
PRL	0.33**	0.36**	0.40**	0.47**	-0.02
PDE	-0.24	-0.25	-0.24	-0.09	0.24
FST	0.29*	0.19	-0.02	-0.01	0.12
SG	0.65**	0.66**	0.67**	0.66**	-0.32*
PHT	0.47**	0.50**	0.50**	0.37**	0.48**
EHT	0.41**	0.45**	0.44**	0.34**	0.50**
PFI	0.96**	0.96**	0.93**	0.49**	-0.40**

*,**Significant at the 5% and 1% level of probability, respectively.

Trait						
PRL	PDE	FST	SG	PHT	EHT	PFI
%	%	#/plot	1-9	cm	cm	
0.26*	0.06	0.36**	0.67**	0.55**	0.47**	0.91**
0.27*	0.06	0.04	0.71**	0.62**	0.54**	0.95**
0.26*	0.06	-0.16	0.69**	0.62**	0.53**	0.91**
0.41**	0.01	0.02	0.67**	0.46**	0.39**	0.61**
0.02	0.43**	-0.17	-0.02	0.56**	0.55**	-0.31*
	-0.10	-0.02	0.27*	0.28*	0.29*	0.17
-0.22		0.07	0.18	0.38**	0.38**	-0.06
-0.18	-0.06		-0.01	-0.10	-0.12	0.09
0.51**	-0.17	0.06		0.66**	0.65**	0.64**
0.51**	0.08	-0.06	0.47**		0.96**	0.42**
0.51**	0.08	-0.08	0.49**	0.94**		0.35**
0.27*	-0.30*	0.23	0.63**	0.32*	0.26*	

plant and ear heights. Correlations of grain yield with the performance index (PFI) were large, ranging from 0.91 to 0.96.

Increased M was correlated with increased PRL, SG, PHT, EHT, and PFI in both tillage systems (Table 86). The correlation coefficients were similar for both tillage systems. PSL was positively correlated with PHT and EHT, and negatively correlated with PFI in each tillage system. Taller plants tended to have more stalk lodging. PRL was positively associated with increased SG, PHT, and EHT in both tillage systems. The correlations were somewhat larger in fall plow than no-till. SG was correlated with PHT, EHT, and PFI in both tillage systems. Correlations of SG, PHT, and EHT with PFI were 0.64, 0.42, and 0.35, respectively, in no-till, and 0.63, 0.32, and 0.26, respectively, in fall plow.

The early vigor traits in general were significantly correlated in both tillage systems, aside from the EMI trait (Table 87). Correlations were similar in both tillage systems. The possible exception was the correlation between EPHT and PEM, which was 0.43 in no-till, and 0.05 in fall plow. EMI was negatively correlated with the other vigor traits in both tillage systems, but the only significant correlation was between EV and EMI in no-till (-0.38).

Days to 50% pollen shed (PS2) and days to 50% silking (SK2) were highly correlated in both tillage systems (Table 88). SK2 and PS2 were positively and significantly correlated with PI in both tillage systems and with SKI in no-till. A later pollen shedding and silking date was associated with a longer pollen shedding interval in both tillage

Table 87. Simple correlations among early vigor traits in Experiment 3, within tillage systems, using entry-tillage means. Coefficients above the diagonal are correlations in no-till, and below the diagonal are correlations in fall plow

	Trait				
Trait	PEM	EV	EMI	EPHT	BMPP
	%	1-9	days	cm	cm
PEM		0.66**	-0.13	0.43**	0.84**
EV	0.51**		-0.38**	0.50**	0.69**
EMI	-0.12	-0.23		-0.12	-0.13
EPHT	0.05	0.58**	-0.02		0.83**
BMPP	0.65**	0.76**	-0.08	0.79**	

**Significant at the 1% level of probability.

Table 88. Simple correlations among pollen sheddding and silking traits, within tillage systems, using entry tillage means. Coefficients above the diagonal are correlations in no-till, and below the diagonal are correlations in fall plow

	Trait				
Trait	PS2	SK2	PI	SKI	PSKI
	days	days	days	days	days
PS2		0.95**	0.30*	0.50**	-0.09
SK2	0.86**		0.27*	0.52**	0.19
PI	0.47**	0.29*		0.48**	-0.03
SKI	-0.14	-0.12	0.11		0.02
PSKI	-0.63**	-0.18	-0.46**	0.13	

*,**Significant at the 5% and 1% level of probability, respectively.

systems, and with a longer silk interval in no-till.

All grain yield traits had a significant negative correlation with increased EPHT in both tillage systems (Table 89). Grain moisture (M) was negatively associated with EPHT and BMPP in no-till, and with EV, EPHT, and BMPP in fall plow. Increased early vigor was associated with larger FST in both tillage systems. EPHT was negatively correlated with SG, PHT, EHT, and PFI in no-till, and with SG in fall plow. Increased early vigor was negatively associated with grain yield, aside from the effect of improving FST.

Correlations of agronomic traits with pollen shedding and silking traits are listed in Table 90. For both tillage systems, large PS2 or SK2 values were positively and significantly associated with increased grain yield (GPMS, GPMSA, WPP), M, PSL, PRL, SG, PHT, EHT, and PFI. Correlations were slightly greater in no-till than fall plow. In no-till, SKI had significant positive correlations with GPMSA, WPP, M, PSL, SG, PHT, and EHT. In fall plow, PSKI had significant positive correlations with GPMSA and WPP, and significant negative correlations with PHT and EHT.

Correlations of early vigor traits with pollen shedding and silking traits are listed in Table 91. Associations were very similar in both tillage systems. Increased early vigor was associated with earlier pollen shedding and silking dates, and reduced pollen shedding and silking intervals. PSKI was relatively uncorrelated with the early vigor traits.

Table 89. Correlations of agronomic traits with early vigor traits in Experiment 3, for (a) no-till and (b) fall plow. Simple product moment correlation coefficients are listed, which were calculated using entry-tillage means

	Trait				
Trait	PEM	EV	EMI	EPHT	BMPP
	%	1-9	days	cm	cm
(a) Correlations in no-till					
GPMS, g/m^2	0.24	0.25	-0.06	-0.36**	-0.08
GPMSA, g/m^2	-0.03	0.10	-0.06	-0.50**	-0.32*
WPP, g	-0.20	-0.03	-0.03	-0.52**	-0.43**
M, %	-0.10	-0.08	-0.01	-0.60**	-0.40**
PSL, %	-0.11	-0.15	0.11	0.02	-0.05
PRL, %	-0.11	-0.08	0.00	-0.14	-0.13
PDE, %	0.15	0.05	0.03	0.00	0.09
FST, #/plot	0.84**	0.56**	-0.11	0.28*	0.66**
SG, 1-9	-0.04	0.05	0.05	-0.40**	-0.25
PHT, cm	-0.06	-0.04	0.13	-0.29*	-0.20
EHT, cm	-0.04	0.00	0.14	-0.27*	-0.18
PFI	0.03	0.17	-0.10	-0.43**	-0.26*
(b) Correlations in fall plow					
GPMS, g/m^2	0.17	-0.01	0.00	-0.37**	-0.19
GPMSA, g/m^2	0.11	-0.03	0.01	-0.37**	-0.23
WPP, g	0.00	-0.12	0.05	-0.42**	-0.34**
M, %	-0.06	-0.35**	0.22	-0.62**	-0.53**
PSL, %	0.00	0.14	-0.03	0.17	0.15
PRL, %	-0.08	-0.21	0.10	-0.32*	-0.30*
PDE, %	0.08	-0.09	0.04	-0.11	-0.03
FST, #/plot	0.59**	0.31*	-0.14	0.11	0.45**
SG, 1-9	-0.03	-0.19	0.22	-0.40**	-0.32*
PHT, cm	-0.05	-0.10	0.18	-0.19	-0.17
EHT, cm	-0.03	-0.03	0.14	-0.18	-0.14
PFI	0.13	0.00	-0.02	-0.31	-0.17

*,**Significant at the 5% and 1% level of probability, respectively.

Table 90. Correlations of agronomic traits with pollen shedding and silking traits in Experiment 3, for (a) no-till, and (b) fall plow. Simple product moment correlation coefficients are listed, which were calculated using entry-tillage means

	Trait				
Trait	PS2	SK2	PI	SKI	PSKI
	days	days	days	days	days
(a) Correlations in no-till					
GPMS, g/m^2	0.55**	0.60**	-0.02	0.19	0.09
GPMSA, g/m^2	0.62**	0.65**	0.06	0.29*	0.02
WPP, g	0.63**	0.64**	0.14	0.35**	-0.02
M, %	0.53**	0.62**	0.19	0.26*	0.21
PSL, %	0.47**	0.45**	0.15	0.26*	0.13
PRL, %	0.25	0.27*	0.26*	0.13	0.07
PDE, %	0.37**	0.37**	0.11	0.21	0.04
FST, #/plot	-0.11	-0.05	-0.33*	-0.29*	0.22
SG, 1-9	0.64**	0.70**	0.16	0.38**	0.19
PHT, cm	0.84**	0.85**	0.23	0.50**	0.00
EHT, cm	0.82**	0.83**	0.25	0.49**	0.04
PFI	0.43**	0.45**	-0.02	0.18	-0.01
(b) Correlations in fall plow					
GPMS, g/m^2	0.50**	0.52**	0.20	-0.22	-0.24
GPMSA, g/m^2	0.52**	0.53**	0.20	-0.22	0.26*
WPP, g	0.53**	0.52**	0.26*	-0.19	0.28*
M, %	0.47**	0.60**	0.27*	-0.01	-0.05
PSL, %	0.34**	0.29*	-0.01	-0.04	-0.22
PRL, %	0.38**	0.42**	-0.01	-0.18	-0.11
PDE, %	0.08	0.04	0.08	0.18	-0.09
FST, #/plot	-0.07	0.07	0.18	-0.12	0.18
SG, 1-9	0.42**	0.49**	0.15	-0.06	-0.10
PHT, cm	0.72**	0.72**	0.19	-0.09	-0.33*
EHT, cm	0.71**	0.67**	0.14	-0.15	-0.40**
PFI	0.36**	0.36**	0.16	-0.22	-0.21

*,**Significant at the 5% and 1% level of probability, respectively.

Table 91. Correlations of early vigor traits with pollen shedding and silking traits in Experiment 3, for (a) no-till, and (b) fall plow. Simple product moment correlations coefficients are listed, which were calculated using entry-tillage means

	Trait				
Trait	PS2	SK2	PI	SKI	PSKI
	days	days	days	days	days
(a) Correlations in no-till					
PEM, %	-0.16	-0.09	-0.33**	-0.31*	0.26*
EV, cm	-0.24	-0.17	-0.32*	-0.28*	0.20
EMI, days	0.13	0.19	0.32*	0.25	0.09
EPHT, cm	-0.55**	-0.53**	-0.21	-0.34**	0.07
BMPP, cm	-0.40**	-0.35**	-0.32*	-0.36**	0.19
(b) Correlations in fall plow					
PEM, %	0.00	0.10	-0.11	-0.37**	0.12
EV, 1-9	-0.29*	-0.28*	-0.27*	-0.35**	0.09
EMI, days	0.05	0.11	0.02	0.27*	0.08
EPHT, cm	-0.55**	-0.59**	-0.40**	0.04	0.19
BMPP, cm	-0.42**	-0.38**	-0.38**	-0.18	0.22

*,**Significant at the 5% and 1% level of probability, respectively.

Correlations of traits in no-till with traits in fall plow The correlations of agronomic traits measured in no-till with measurements in fall plow are listed in Table 92. Values on the diagonal represent the correlations of entry means for a trait in no-till with entry means for the same trait in fall plow, i.e., how well the expression of a trait correlates across tillage systems. Off-diagonal values represent the correlation of entry means for a trait in one tillage system with entry means for other traits in the alternate tillage system. The expression of agronomic traits correlated well across tillage systems. Of the 12 traits considered, 2 had correlations above 0.90, 2 were near 0.85, and 5 were in the 0.68 to 0.80 range. PDE did not correlate across tillage systems. The correlations for FST was near 0.30, and about 0.50 for PRL. Traits with high repeatability estimates generally correlated well across tillage systems.

The correlations across tillage systems for early vigor traits ranged from 0.40 to 0.80 (Table 93). PEM had the highest and EMI had the lowest correlation coefficient across tillage systems. This indicates that expression of early vigor traits correlated only moderately well across tillage systems. The correlation coefficients were lower than for most of the agronomic characters.

Correlations across tillage systems for pollen shedding and silking traits are listed in Table 94. PS2 and SK2 correlated well across tillage systems, with correlation coefficients ranging from 0.75 to 0.85. PI, SKI, and PSKI did not have significant correlations across tillage systems.

Table 92. Phenotypic correlations in Experiment 3, of agronomic trait measurements in no-till with agronomic trait measurements in conventional tillage, using entry-tillage means. Simple product moment correlations are listed. The coefficients on the diagonal to the right of the slash mark are Spearman rank correlation coefficients

No-till traits	Fall plow traits			
	GPMS	GPMSA	WPP	M
	g/m^2	g/m^2	g	%
GPMS	0.75**/0.72**	0.74**	0.71**	0.68**
GPMSA	0.77**	0.76**/0.75**	0.74**	0.69**
WPP	0.73**	0.73**	0.73**/0.71**	0.69**
M	0.71**	0.71**	0.70**	0.79**/0.77**
PSL	-0.14	-0.11	-0.12	-0.15
PRL	0.18	0.20	0.22	0.37**
PDE	-0.03	-0.02	-0.03	-0.10
FST	0.13	0.10	0.05	0.04
SG	0.64**	0.65**	0.66**	0.65**
PHT	0.46**	0.48**	0.47**	0.37**
EHT	0.39**	0.42**	0.40**	0.30*
PFI	0.73**	0.72**	0.69**	0.63**

*,**Significant at the 5% and 1% level of probability, respectively.

Fall plow traits			
PSL	PRL	PDE	FST
%	%	%	#/plot
-0.13	0.42**	-0.06	0.21
-0.07	0.46**	-0.04	0.17
-0.05	0.45**	-0.04	0.08
-0.19	0.52**	-0.18	0.09
0.86**/0.86**	0.05	0.12	-0.12
0.00	0.59**/0.42**	-0.25	-0.13
0.40**	0.19	-0.01/0.08	0.05
-0.17	-0.05	0.07	0.30*/0.27*
-0.05	0.54**	-0.08	0.05
0.56**	0.47**	0.07	-0.01
0.58**	0.46**	0.05	-0.02
-0.28*	0.37**	-0.03	0.21

Table 92. (Continued)

No-till traits	Fall plow traits			
	SG	PHT	EHT	PFI
	1-9	cm	cm	
GPMS	0.63**	0.55**	0.48**	0.67**
GPMSA	0.66**	0.61**	0.56**	0.67**
WPP	0.64**	0.61**	0.55**	0.64**
M	0.61**	0.44**	0.42**	0.62**
PSL	-0.34**	0.49**	0.47**	-0.30*
PRL	0.28*	0.27*	0.26*	0.13
PDE	-0.07	0.33**	0.36**	-0.10
FST	0.01	-0.09	-0.15	0.15
SG	0.84**/0.84**	0.68**	0.71**	0.56**
PHT	0.43**	0.95**/0.94**	0.94**	0.28*
EHT	0.41**	0.90	0.96**/0.96**	0.22
PFI	0.68**	0.44**	0.39**	0.69**/0.68**

Table 93. Phenotypic correlations in Experiment 3, of early vigor trait measurements in no-till with early vigor trait measurements in fall plow, using entry-tillage means. Simple product moment correlation coefficients are listed. The coefficients on the diagonal to the right of the slash mark are Spearman rank correlation coefficients

	Fall plow traits				
No-till traits	PEM	EV	EMI	EPHT	BMPP
	%	1-9	days	cm	cm
PEM	0.79**/0.68**	0.39**	-0.10	0.08	0.53**
EV	0.57**	0.61**/0.55**	-0.06	0.26*	0.54**
EMI	-0.19	-0.27*	0.46**/0.40**	-0.03	-0.12
EPHT	0.18	0.38**	-0.05	0.57**/0.47**	0.53**
BMPP	0.58**	0.45**	-0.07	0.39**	0.63**/0.61**

*,**Significant at the 5% and 1% level of probability, respectively.

Table 94. Phenotypic correlations in Experiment 3, of pollen shedding and silking trait measurements in no-till with pollen shed and silking traits measured in fall plow, using entry-tillage means. Simple product moment correlation coefficients are listed. The coefficients on the diagonal to the right of the slash mark are Spearman rank correlation coefficients

	Fall plow traits				
No-till traits	PS2	SK2	PI	SKI	PSKI
	days	days	days	days	days
PS2	0.84**/0.83**	0.77**	0.25	0.10	-0.49**
SK2	0.79**	0.78**/0.75**	0.21	-0.15	0.37**
PI	0.28*	0.31*	0.19/0.20	0.17	-0.09
SKI	0.44**	0.41**	0.41**	0.07/0.07	-0.24
PSKI	-0.05	0.07	-0.09	-0.11	0.21/0.23

*,**Significant at the 5% and 1% level of probability, respectively.

Correlations of the early vigor traits in one tillage system with the agronomic traits in the alternate tillage system are listed in Table 95. Values were similar in Table 95a, in which correlations of no-till agronomic traits with fall plow early vigor traits are listed, and Table 95b, in which correlations of fall plow agronomic traits with no-till vigor traits are listed. EPHT was negatively correlated with GPMS, GPMSA, WPP, M, and SG in both cases, and also had significant negative correlations with PRL, PHT, and EHT in Table 95b.

Selection of hybrids

Hybrids were selected using GPMS, GPMSA, and a performance index (PFI). Selection for each criterion will be discussed individually. As for Experiments 1 and 2, selection within sets was used, selecting equal numbers within each set.

The hybrids selected by each of the three selection criterion are listed in Table 96. For GPMS, 3 out of the 6 hybrids selected for each tillage system with a 10% selection intensity were in common to the two groups, and 7 out of 12 were in common for a 20% selection intensity.

The difference in yield between the selected groups in fall plow was 45 g/m^2 for the 10% selection intensity groups, and 41 g/m^2 for the 20% selection intensity groups (Table 97). This difference was not significant, as tested by an LSD. In fall plow, the mean for the fall plow selection group was 935 g/m^2, and the mean for the corresponding no-till group was 891 g/m^2, with a 10% selection. The difference in yield in no-till was 26 g/m^2 for the 10% selection intensity groups, and 21 g/m^2 for the 20% selection intensity groups (Table 98). Neither

Table 95. Phenotypic correlations in Experiment 3, of (a) agronomic traits measured in no-till with early vigor traits measured in fall plow, and (b) agronomic traits measured in fall plow with early vigor traits measured in no-till, using entry-tillage means. Simple product moment correlation coefficients are listed

No-till traits	Fall plow traits				
	PEM	EV	EMI	EMPH	BMPP
	%	1-9	days	cm	cm
(a) No-till agronomic traits with fall plow vigor traits					
GPMS, g/m^2	0.21	-0.13	0.19	-0.49**	-0.26*
GPMSA, g/m^2	0.05	-0.16	0.18	-0.50**	-0.36**
WPP, g	-0.10	-0.22	0.15	-0.50**	-0.45**
M, %	0.06	-0.16	0.19	-0.51**	-0.36**
PSL, %	-0.12	0.04	0.01	0.16	0.06
PRL, %	-0.06	-0.08	0.23	-0.11	-0.12
PDE, %	0.14	0.18	-0.22	0.04	0.11
FST, #/plot	0.61**	0.17	0.04	-0.04	0.32*
SG, 1-9	0.04	-0.05	0.15	-0.31*	-0.21
PHT, cm	0.00	-0.02	0.17	-0.15	-0.11
EHT, cm	0.03	0.06	0.10	-0.10	-0.06
PFI	0.08	-0.15	0.14	-0.48**	-0.33*

Fall plow traits	No-till traits				
(b) Fall plow agronomic traits with no-till traits					
GPMS, g/m^2	0.06	0.18	-0.28*	-0.40**	-0.20
GPMSA, g/m^2	0.04	0.16	-0.26*	-0.39**	-0.21
WPP, g	-0.02	0.10	-0.22	-0.39**	-0.25
M, %	-0.06	-0.09	0.15	-0.49**	-0.33*
PSL, %	-0.04	-0.06	0.12	0.09	0.03
PRL, %	-0.11	-0.04	-0.06	-0.33*	-0.27*
PDE, %	0.05	-0.11	0.17	0.12	0.09
FST, #/plot	0.31*	0.32*	-0.16	-0.02	0.17
SG, 1-9	-0.08	0.02	0.03	-0.39**	-0.28*
PHT, cm	-0.09	-0.05	0.14	-0.27*	-0.21
EHT, cm	-0.08	-0.04	0.14	-0.30*	-0.22
PFI	0.07	0.20	-0.32*	-0.33*	-0.16

*,**Significant at the 5% and 1% level of probability, respectively.

Table 96. Entry numbers of genotypes selected in no-till (NT) and fall plow (FP), with three different selection criteria, for Experiment 3

Selection		Selection criterion					
		GPMS		GPMSA		PFI	
Set	Rank	NT	FP	NT	FP	NT	FP
		g/m^2		g/m^2			
1	1	43	51	57	51	43	51
	2	52	58	43	58	57	58
	3	57	56	56	43	56	56
	4	51	43	58	56	58	43
2	1	67	64	67	64	67	67
	2	77	67	77	67	80	64
	3	62	62	80	62	77	80
	4	80	80	62	80	71	79
3	1	82	82	82	82	82	82
	2	99	99	99	99	99	99
	3	81	97	97	97	97	97
	4	91	100	84	100	91	100
No. in common:							
10% selection		3/6		3/6		3/6	
20% selection		7/12		9/12		8/12	

Table 97. Mean fall plow grain yields of groups selected in no-till (NT) and fall plow (FP), based on GPMS and GPMSA, for Experiment 3

Selection criterion	Selection intensity	FP selection in FP	NT selection in FP	Difference[a]
		g/m^2	g/m^2	g/m^2
GPMS	10%	936	891	45
	20%	909	868	41
GPMSA	10%	934	903	31
	20%	909	890	19

[a]None of the differences were statistically significant, when tested by an LSD.

Table 98. Mean no-till yields of groups selected in no-till (NT) and fall plow (FP), based on GPMS and GPMSA, for Experiment 3

Selection criterion	Selection intensity	NT selection in NT	FP selection in NT	Difference[a]
		g/m^2	g/m^2	g/m^2
GPMS	10%	875	849	26
	20%	849	828	21
GPMSA	10%	862	836	26
	20%	836	825	11

[a]None of the differences were statistically significant, when tested by an LSD.

of these differences were significant as tested by an LSD. The mean for the 10% selection intensity groups in no-till was 875 g/m^2 for the no-till selections and 849 g/m^2 for the fall plow selections.

When GPMSA was used as a selection criterion, 3 out of 6 selections were in common to the fall plow and no-till groups with a 10% selection intensity, and 9 out of 12 were in common with a 20% selection intensity (Table 96). The difference between the 10% selection intensity groups in fall plow was 31 g/m^2, and the difference was 19 g/m^2 for the 20% selection (Table 97). The difference in group means in no-till for the 10% selection intensity groups was 26 g/m^2, and for the 20% selection intensity groups the difference was 11 g/m^2 (Table 98).

Even though these differences were not significant, the effect of selection in one year and evaluation in the alternate year was examined. A 20% selection intensity was used, in order to have the group means based on more than 6 entries. GPMS was the selection criterion. The results indicate that differences observed in the selection year were not transmitted to the evaluation year, to any great extent (Table 99).

A performance index (PFI) using repeatabilities as b-values and unstandardized values was calculated, using the traits GPMS, M, PSL, PRL, and PDE. When hybrids were selected from each tillage system using PFI as the selection criterion, 3 of the 6 selections for each tillage system were in common with a 10% selection and 8 of 12 were in common with a 20% selection intensity (Table 96). One group was

Table 99. Grain yields of groups selected in one year and evaluated in the alternate year, for Experiment 3. Selection was based on GPMS with a 20% selection intensity

Selection group and tillage system	Selection in 1981, evaluation in 1982		Selection in 1982, evaluation in 1981	
	1981	1982	1982	1981
	g/m^2	g/m^2	g/m^2	g/m^2
FP selection, in FP	943	863	905	891
NT selection, in FP	877	848	862	887
Advantage	66	15	43	4
NT selection, in NT	901	776	829	841
FP selection, in NT	869	785	794	835
Advantage	32	-9	25	6
FP mean	797	763	763	797
NT mean	738	692	692	738

selected for each tillage system using PFI as the selection criterion and a 20% selection intensity. The means of these groups for five traits in each tillage system are listed in Table 100. Trait means were calculated for GPMS, M, PSL, PRL, and BMPP. The PDE trait was not included because dropped ears were a very minor problem for these hybrids, and BMPP was included to provide a single measure of early vigor. In addition, trait means obtained by selecting for GPMS alone with a 20% selection intensity are listed, to provide a basis of comparison for selection with PFI.

Very little difference between the fall plow PFI selections and the no-till PFI selections was noted, except for a difference in grain yield (Table 100). When PFI selection was compared to GPMS selection, only minor differences were observed. It can be noted from Table 96 that 11 of the 12 selections for fall plow PFI and fall plow GPMS were in common.

The main difference between the performance of the no-till PFI selections and the fall plow PFI selections in no-till was for grain yield. PSL was somewhat lower for the no-till selections. The PFI no-till selections had 17 g/m^2 lower grain yield, and 2.1% less stalk lodging than the GPMS no-till selections. Eight of the 12 selections obtained with a 20% selection for PFI in no-till and the 12 obtained with a 20% selection for GPMS in no-till were in common (Table 96). Grain yield had the greatest influence for the performance index used in this study.

Table 100. Mean for five traits of groups selected using (a) a performance index (PFI) and (b) grain yield (GPMS), within each tillage system. A 20% selection intensity was applied

Selection criterion	Selection group and tillage system	Trait GPMS	M	PSL	PRL	BMPP
		g/m^2	%	%	%	cm
Performance index (PFI)	FP selection in FP	903	21.4	7.4	2.3	287
	NT selection in FP	875	21.8	7.4	2.2	292
	Difference	28	-0.4	0.0	0.1	-5
	NT selection in NT	832	22.5	7.1	1.0	170
	FP selection in NT	809	22.3	8.3	0.9	168
	Difference	23	0.2	-1.2	0.1	2
GPMS	FP selection in FP	909	21.7	7.9	2.8	289
	NT selection in FP	868	21.6	9.4	2.6	290
	Difference	41	0.1	-1.5	0.2	-1
	NT selection in NT	849	22.5	9.2	1.0	166
	FP selection in NT	828	22.7	9.3	1.1	167
	Difference	21	-0.2	-0.1	-0.1	-1
Fall plow mean:		780	20.4	9.8	2.1	306
No till mean:		715	21.0	10.3	0.7	175

DISCUSSION

Effect of Tillage Upon Performance of S_1-lines From Experiment 1 and Experiment 2

The no-till system caused a substantial reduction in early vigor for the S_1-lines from both populations in 1981 (Tables 7 and 40). In 1982 at Kanawha, early vigor means were similar for the two tillage systems, and at Nashua and Ames in 1982, the reduction in early vigor due to no-till was much less than in 1981. Early plant height in Experiment 2 was the only early vigor trait with a significant genotype by tillage interaction. However, the biomass per plot rating in Experiment 2, and percentage emergence in both experiments, had significant genotype by tillage by environment interactions. These means and interactions suggested that the environment was a major factor governing the effect of tillage on genotypic variation for early vigor.

For BS13(SCT)C6, all estimates of genotypic variance for the early vigor traits were greater in fall plow than no-till, and for early plant height and the biomass per plot rating, the differences were larger than two standard errors (Table 43). The means and variances expressed across tillage systems for the population were similar to those for BS22(R)C1, but the BS22(R)C1 population had no trends toward greater genotypic variance in one tillage system versus the other. The effect of the cold tolerance selection for BS13(SCT)C6 done in a fall plow system upon the means and variances expressed could not be examined with this study, but certainly could have affected the observed results.

The effect of tillage on pollen shedding and silking dates was statistically significant for both populations (Tables 11 and 44). Pollen-shedding interval, silking interval, and pollen-shedding-to-silking interval were traits of relatively low heritability, but tended to be longer in no-till than fall plow for both populations. Interactions between genotypes and tillage systems for pollen shedding and silking traits were present in each population.

A tendency toward expression of more genotypic variation for pollen shedding and silking traits in no-till than fall plow was noted for both populations, but the heritability estimates were similar in both tillage systems (Tables 10 and 43). The increase in variation in no-till seemed to be a general increase over all sources of variation, and was probably related to the delayed anthesis and silking dates observed in no-till relative to fall plow.

Significant variation due to tillage was noted for plant height and ear height in both experiments, but interactions between genotypes and tillage systems were not significant (Tables 14 and 47). Plant heights were shorter in no-till, but the reductions in height were a general, rather than genotype specific, effect. Stay green had significant tillage by environment and genotype by tillage interactions in Experiment 1 (Table 14), whereas in Experiment 2, no significant tillage effects or tillage interactions were noted (Table 47). Means for stay green in no-till and fall plow were only 0.2 units apart in Experiment 1 (Table 15); therefore, the genotype by tillage interaction must have been caused by changes in ranking rather than only by changes in magnitude. Stay green had significantly more genotypic variation and a higher heritability in no-till than fall plow for Experiment 1 (Table 8), whereas the genotypic variance for stay green was 1.24 standard errors larger in fall plow than no-till in Experiment 2 (Table 41). The effect of tillage on stay green was dependent upon the base population.

Tillage had a significant effect on the three grain yield traits examined in both experiments. Grain yield means were higher for the BS13(SCT)C6 S_1-lines, but environment-tillage means followed the same pattern in both experiments. Both populations had significant interactions between genotypes and tillage systems for at least one of the grain yield traits (Tables 19 and 52).

Genotypic variance estimates from S_1-lines provide an estimate of $\sigma_A^2 + 1/4\sigma_D^2$ for the base population. Hallauer and Miranda (1981) suggested that S_1-lines can provide a fairly accurate and simple estimate for additive genetic variances, because dominance estimates are generally small relative to estimates for additive genetic variance. From the anovas over tillage systems for grain yield, it appeared that the BS22(R)C1 population had more additive genetic variation for grain yield than the BS13(SCT)C6 population. Significantly more genotypic variation was observed in no-till than fall plow in Experiment 1 (Table 18), but more genotypic variation was observed in fall plow for Experiment 2 (Table 51). No-till estimates of σ_G^2 for grain yield were smaller for Experiment 2 than Experiment 1, whereas in fall plow, the opposite was true. The expression of additive genetic variance for grain yield in no-till versus fall plow was markedly different for the two populations used.

Grain moisture was relatively unaffected by tillage in both experiments, as no sources involving tillage were significant in either experiment (Tables 19 and 52). The genotypic variance was greater in no-till than fall plow in both experiments (Tables 18 and 51), probably due to the somewhat higher grain moisture in no-till.

Expression of both lodging traits was affected by tillage systems. Both percentage stalk lodging and percentage root lodging had significant interactions involving genotypes and tillage in each experiment. Interactions of genotypes with tillage systems may have been due to changes in magnitude, rather than changes in ranking, as means were generally larger in fall plow than no-till.

Mean final stand was reduced by tillage at Ames in 1981 in both experiments, but differences between tillage system means were minor for all other environments (Tables 20 and 53). The original intention of the study was to obtain uniform stands of 48 plants/plot (57,400 plants/ha), so that genotypic variation for grain yield would not be confounded with variation for final stand. However, the regression of grain yield on stand obtained with a covariance analysis was significant for 4 environment-tillage blocks for Experiment 1 and for 3 environment-tillage blocks for Experiment 2. Thinning reduced genotypic variation for FST substantially, which can be noted by comparing the FST anova with the PEM anova, but the percentage emergence for some entries in 1981 was too low to eliminate genotypic variation for FST entirely.

The effect of tillage upon within plot variability was difficult to interpret. The coefficient of variability means were larger in no-till than fall plow for both experiments (Tables 23 and 56). However, the differences were due largely to reduced means for plant height, ear height, and early plant height in no-till, because none of the within plot standard errors had significant effects due to tillage (Tables 22 and 55), and for 5 of the 6 cases, were larger in fall plow than no-till (Tables 23 and 56).

The only report to date involving evaluation of unselected maize genotypes in two tillage systems is that of Brakke et al. (1983). The genotypes included were topcrosses of an extremely diverse group of genetic material: 73 hybrids, 37 populations, 13 inbred lines, and 40 topcrosses. The tester was a population formed from a Corn Belt by Rumanian population cross. Brakke et al. (1983) reported significant cropping system effects and genotype by cropping system interactions for days to half-silk, plant height, grain yield, and harvest moisture. The cropping systems used were probably more diverse than the tillage systems used in this study, and no defined base population for the genotypes was readily obvious. Interactions of genotypes with tillage systems were observed in the present study, but it is not surprising that fewer were observed than for the Brakke et al. (1983) study.

The potential problem of reduced genotypic variance and heritability in no-till relative to fall plow was not observed for the S_1-lines used in this study. In Experiment 1, six traits had significantly greater genotypic variance expressed in no-till than fall plow (Tables 10 and

and 18), two traits had significant genotypic variation in no-till but not in fall plow (Tables 13 and 21), and one trait had significant genotypic variation in fall plow but not in no-till (Table 21). Three traits had significantly greater genotypic variance expressed in fall plow than no-till for Experiment 2, (Tables 43 and 52), and two traits had significant genotypic variation in no-till but not fall plow (Tables 46 and 54). One possible explanation for the tendency of the BS22(R)C1 S_1-lines to have greater genotypic variance in no-till than fall plow was that no cold tolerance selection has been done in BS22. Six cycles of S_1-line *per se* recurrent selection have been done for BS13(SCT)C6, and genotypic variance tended to be equal for the two tillage systems, or greater in fall plow. This cannot be verified with the genetic material in this study. Heritability values were similar for both tillage systems, in both experiments. Based on these data, response to selection done in no-till should be similar to the response which has been observed for fall plow.

Correlations in Experiment 1 indicate that for the S_1-lines from BS22(R)C1, plant size and grain filling period may be limiting factors for grain yield (Table 24). The association of no-till grain yields with early vigor traits in no-till was primarily due to the effect on final stand, because 4 of the 5 early vigor traits were significantly correlated with grain yield, and only early plant height had a significant (but small) correlation with grain yield adjusted for stand (Table 27). Increased grain yield was positively correlated with increased early vigor in both tillage systems (Table 60). The correlations of grain yield with percentage emergence and final stand were smaller in Experiment 2 than Experiment 1, probably due to the fact that only 40 of the 100 S_1-lines used for Experiment 2 were grown in 1981. As with Experiment 1, increased early vigor was associated with earlier dates for pollen shedding and silking (Table 62). The correlations indicated that desired genotypes for no-till (or fall plow) should have high percentage emergence to provide a good stand, large early plant height, and a high stay green rating. Correlations of these traits with pollen shed and silking dates indicated that selection for these three traits may be counter-productive, even though percentage emergence and early plant height were relatively uncorrelated with stay green.

Good correspondence for agronomic characters across tillage systems was noted (0.60 to 0.85), but correlations were not so high as to indicate that genotypic effects expressed in one system were exactly the same as expression in alternate system (Tables 30 and 63). Correlation of the early vigor traits across tillage systems was relatively low in Experiment 1, and variable for Experiment 2 (Tables 31 and 54). The correlations of early vigor traits in one tillage system with grain yield in the alternate tillage system were very low (Tables 33 and 66). The rank correlations between cropping systems in the Brakke et al. (1983) study for days to half-silk and plant height were very low, and rank correlation coefficients were actually negative for grain yield and harvest moisture. These data agree with the suggestion that the cropping systems and genotypes were more diverse for the Brakke et al. (1983) study than for the present study.

In both experiments, different lines were selected in no-till than fall plow, for all four selection criteria. Grain yields of the groups were usually different, in the sense that a significantly larger selection differential was obtained by selecting within the system in which evaluation would be done. Results for selection and evaluation for Experiment 1 indicated that no-till selection was more effective in improving no-till grain yield than fall plow selection (Table 37). For Experiment 2, the results were inconclusive (Table 70).

Effect of Tillage Upon Performance of Commercial Hybrids From Experiment 3

Early vigor for the hybrids was reduced substantially in no-till relative to fall plow in 1981 at both locations (Table 73). Only minor reductions were noted in 1982. Mean early plant height reduction in no-till relative to fall plow was 35% over years and environments, and ranged from 13-44% for the individual environments. This range was comparable to the range of 15-37% reduction for five environments reported by Griffith et al. (1973), and was greater than reductions reported by Mock and Erbach (1977). Tillage induced effects on percentage emergence varied widely between years; similar findings were reported by Mock and Erbach (1977). The tillage by environment interactions were significant for all the early vigor traits, whereas the tillage source was not (Table 72). Repeatability estimates were generally larger in fall plow than no-till (Table 74).

The hybrids flowered about 4 days later in no-till than fall plow (Table 76), with no evidence of a genotype by tillage interaction (Table 75). Brakke et al. (1983) reported a similar delay (3.4 days) for the ecofallow system which they used. Effects due to cropping systems and genotype by cropping system were significant in their study. Even though no-till had only relatively minor effects on early vigor at Ames in 1981, hybrids still flowered around two days later in no-till relative to fall plow. Either small differences in above ground early vigor can result in substantial differences in days to flowering, or additional tillage induced effects were contributing to the delay. Means for plant and ear heights were reduced in no-till 6 cm and 8 cm, respectively. Both had significant interactions involving genotypes and tillage. Plant and ear heights were lower in no-till in every environment. These data were consistent with data reported by Brakke et al. (1983), but significant interactions of genotypes with tillage systems for plant height were not reported by Mock and Erbach (1977), Funnemark (1983), Hallauer (1982), or Mason (1983).

Tillage means over environments might suggest that the reduction in grain yield per unit area was due largely to reduced final stand in no-till (Table 82). However, environments with no final stand differences (Nashua 1981 and Ames 1982) had as much or more grain yield loss as the one environment with a large final stand difference between tillage systems (Ames 1981). Though not indicated by the overall experimental means, reduced grain harvested per plant contributed more to the lower no-till grain yield than reduced final stand. Other studies comparing grain yields in different tillage systems did not employ thinning to uniform stands, and did not report grain weights per plant. Therefore, the relative effects of reduced final stand versus the effects of reduced weight per plant could not be assayed in their studies. Though the mean grain yields in no-till were consistently lower than the mean grain yields in fall plow, the difference was not significant in a combined anova over environments and tillage systems. The same situation was observed by Mason (1983) and Hallauer (1982). For Funnemark (1983) conservation tillage plots actually had a larger mean grain yield than conventional tillage plots, because wind and water damage on the conventional tillage plots was worse than on the conservation tillage plots; however, differences between tillage systems were not significant.

The difference in grain moisture between the two tillage systems was only 0.6% in this study, as compared with a 1.6% difference reported by Hallauer (1982). The present study included hybrids of earlier maturity dates than those used by Hallauer (1982) and mean harvest moistures were lower, resulting in the relatively small tillage effect on grain moisture. It is common belief that conservation tillage systems tend to result in higher grain moisture at harvest. However, significant variation due to tillage was not observed in this study or in studies by Erbach et al. (1980), Funnemark (1983), Hallauer (1982), and Mock and Erbach (1977). In the Brakke et al. (1983) study, the ecofallow system was lower in harvest moisture than the irrigated conventional tillage system.

Correlations between agronomic traits were not different for the two tillage systems. The hybrids included in this study had a wide range in relative maturities, and were adapted to a band covering the area from central Iowa to southern Minnesota. Hybrid means for harvest moisture in fall plow ranged from 18.1 to 24.1%, the range was from 1.4 to 5.6 for stay green, and for days to 50% pollen shed, the range was from 83.0 to 92.3 days. These differences in maturity helped to explain the strong positive correlations of grain yield with grain moisture, stay green, and plant height. The highest yielding hybrids were not completely adapted to northern Iowa's growing environment.

Grain yield was negatively correlated with EPHT in both tillage systems (Table 89). Early plant height was negatively correlated with 50% pollen shed, plant height, ear height, stay green, and grain moisture, all five of which were positively correlated with grain yield (Tables 86, 89, and 90). The associations indicated that increased early growth was associated with earlier physiological maturity. Since the genotypes were fixed, it was not possible to separate the effects caused by specific genotypes from a general physiological phenomena.

Correlations of no-till traits with fall plow were in the 0.70 to 0.75 range for grain yield. This correlation was very similar to the 0.77 rank correlation reported by Mason (1983). The best correlation that could be obtained would be if hybrid means for tillage main plots differed in expression no more than if an additional two replicates were evaluated in each environment. For this case, the correlation would be analogous to correlating entry means over environments for replicates 1 and 2 (no-till) with entry means over environments for replicates 3 and 4 (fall plow). The magnitude of the correlations would be entirely dependent upon the experimental error associated with the trait. For correlations of no-till with fall plow in this experiment, it seemed that this was the case. The magnitude of the correlations between no-till and fall plow were more influenced by the repeatability of the traits within a tillage system than by the effect of genotype by tillage interactions.

The percentage of hybrids selected in both tillage systems was only 50% for the 10% selection intensity groups, and 58-75% for the 20% selection intensity groups, but differences between group means within a tillage system were not significantly different (Tables 96, 97, and 98). No advantage to selection in no-till was observed when selections were made one year and their evaluation done the alternate year (Table 99). Genotypes selected with the performance index which was used differed only slightly from the selections based on grain yield alone (Table 100).

Comparison of Unselected S_1-lines With Commercial Hybrids, and Recommendations for Selection in Maize Breeding Programs

The most striking difference between the hybrids and the S_1-lines was the almost complete lack of genotype by tillage interactions for harvest traits with the hybrids. Grain yield, grain moisture, stalk lodging, and root lodging did not have significant interactions between genotypes and tillage systems in Experiment 3, repeatability estimates were similar for both tillage systems, correlations across tillage systems were relatively high, and significant differences for grain yield between selection groups were not noted. In contrast, the S_1-lines data provided several indications that a different set of lines would be selected in no-till than fall plow. One reason for the discrepancy could be that hybrid vigor alone was sufficient to mitigate genotype by tillage interactions, and that inbreeding depression distorted the magnitude of these interactions. Another explanation could be that commercial hybrids have been developed, evaluated, and selected under conventional tillage, and that lines which would perform relatively better in no-till than fall plow were already eliminated through the selection process. A third possibility could be that such extensive field testing was done prior to release of these hybrids for commercial sales that stress tolerant hybrids were selected, and thereby genotype by tillage interactions were small.

Another discrepancy between the S_1-lines and the hybrids was the correlations of grain yield with early vigor traits. The S_1-lines from both populations had significant positive correlations between early vigor and grain yield within both tillage systems. Hybrid genotypes were, in general, negatively correlated with early vigor, and especially with early plant height. These correlations indicated that hybrids with faster early growth tended to flower earlier and mature earlier, which reduced grain yields because the full growing season was not utilized. The association was probably present because genotypes adapted to a more northern latitude would require good early growth in a cold environment, yet would also be adapted to a shorter growing season. When planted in more southern latitudes, these hybrids would still have better early growth. However, the earlier hybrids would not take full advantage of the longer growing season, resulting in lower grain yields relative to hybrids with a longer growing season.

The results indicated that improved no-till grain yield would probably be best accomplished through selection in no-till. Genotypic variances and heritabilities were generally not reduced in no-till. For the BS22 population, selection in no-till was actually better at identification of superior genotypes than selection in fall plow. Different lines were selected in no-till than fall plow.

Associations between early vigor traits and grain yield were no larger in no-till than fall plow, and there were no marked differences between the effect of no-till on the BS22(R)C1 S_1-lines and on the BS13(SCT)C6 S_1-lines. Correlations might have been different if thinning was not used.

Because grain yields were reduced in no-till relative to fall plow in nearly every environment, the no-till system might be considered a stress environment. Selection in stress environments often carries the conotation that the stress environment is suboptimal relative to targeted environments in which improved varieties would be grown. Accordingly, selection in no-till would not be considered selection in a stress environment if hybrids were then grown in no-till environments. Rosielle and Hamblin (1981) examined theoretical consequences of selection under stress and nonstress environments, and the consequences of selection for tolerance to stress (minimizing grain yield reduction in the stress environment) versus selection for high mean productivity across stress and nonstress environments. Data for grain yield from Experiments 1 and 2 were used to predict the effects of selection in no-till and fall plow upon tolerance and mean productivity. Phenotypic correlations of grain yield from one tillage system to the other were used instead of the genetic correlations recommended by Rosielle and Hamblin (1981). The only other required information was the ratio of genotypic variance in no-till to genotypic variance in fall plow.

Data from Experiment 1 and 2 were different from most stress and nonstress selection studies, because even though the grain yield mean in no-till was lower than in fall plow, the ratio of no-till σ_G^2 to fall plow σ_G^2 was greater than 1 (1.65) for Experiment 1, and only slightly less than 1 (0.86) for Experiment 2. This is contrary to studies done by Frey (1964), Gotoh and Osani (1959), Johnson and Frey (1967), and Mederski and Jeffers (1973), in which genotypic variances were reduced considerably more in the stress environment. Correlations between tillage systems were 0.78 for Experiment 1 and 0.66 for Experiment 2. Experiment 1 represented the most favorable situation on a theoretical level, because stress tolerance, mean productivity, stress grain yield, and nonstress grain yield all would be positively correlated (Rosielle and Hamblin, 1981). For Experiment 2, the correlations between stress tolerance and nonstress yield, and between stress tolerance and mean productivity, would be negative, but small. Correlations of stress tolerance with stress yield, and of stress and nonstress yields with mean productivity would be favorable.

The conclusion of Rosielle and Hamblin (1981) relative to evaluation environments was that the most desirable approach would be to choose testing sites representative of the production conditions for which a breeder wishes to improve mean grain yields. Brown et al. (1983), in a paper describing a method to classify and evaluate testing environments, concluded that the optimum selection environments are those in which: (1) the trait is expressed, (2) genetic variance is maximized, (3) environmental and genotype by environmental variance is minimized, (4) the growing region of the entries included in the test is accurately represented, (5) the environment is acessible for efficient and inexpensive testing of entries, and (6) conditions 1 throught 5 are consistent over years.

When one considers the data from Experiment 1 and 2, it would appear for these populations that genetic variances and heritabilities in a no-till system would not present problems relative to selection. Both Rosielle and Hamblin (1981) and Brown et al. (1983) recommended using testing environments representative of the environments targeted for production of the selected genotypes. Statistics from the Conservation Tillage Information Center (1983) suggests that over half of the total crop acres in Iowa were planted to some form of conservation tillage in 1982, and usage of conservation tillage is almost certain to increase rather than decrease. Given these facts, I would recommend that maize selection programs which are selecting hybrids for use in Iowa should put half of their grain yield selection resources on conservation tillage fields. I would recommend evaluation and selection for traits correlated to grain yield in addition to grain yield and harvest traits. Correlations in this study suggested that selection for increased percentage emergence would be necessary to assure a good final stand. Selection for increased early plant height should promote earlier canopy development and days to 50% pollen shed, and lower grain moisture. To assure full use of the growing season, a high stay green rating would be desired. At harvest, high grain yield, and low grain moisture, stalk lodging, and root lodging would be selected for, as with any hybrid maize selection program. Selection could be done in a tandem S_1-, S_2-line evaluation program, where S_1-lines would be screened for morphological and early vigor traits prior to yield selection of S_2-lines. A base population could be improved for some of the "nonharvest" traits prior to initiating selection for grain yield. Or, an index (mental or defined) could be used to develop the desired types. Because correlations among characters were the same in no-till as for fall plow, similar phenotypes would be desired for both tillage systems.

Additional studies are necessary to examine selection for no-till and other conservation tillage systems. To explore the relationships between cold tolerance and no-till grain yield, one could grow lines from an original and an improved cycle of a population selected for improved cold tolerance. The effect of cold tolerance upon means, variances, and correlations would be examined. To study why the commercial hybrids seemed to respond somewhat differently to no-till than S_1-lines, unselected hybrids could be grown. Using these data, one could determine whether their response to no-till was more similar to the unselected S_1-lines, or more like the response of the selected hybrid genotypes.

To finally determine whether selection in no-till can actually identify inbreds and hybrids which perform relatively better in no-till, it probably will be necessary to implement divergent selection from common base populations, and compare the progress for selection in no-till and in fall plow after a number of cycles of selection.

The above mentioned studies would answer further questions about the feasibility and necessity for no-till selection to be done in no-till environments. The present study could serve as a base line for future studies on no-till and reduced tillage maize breeding and production.

SUMMARY AND CONCLUSIONS

Interactions of genotypes with tillage systems were more common for the unselected S_1-lines than for the commercial hybrids. With the genetic material used in this study, it was not possible to determine whether this was due to the hybrids being elite, selected genotypes, or whether hybrid vigor itself might tend to reduce genotype by tillage interactions.

Even though the no-till system caused reduced early vigor and grain yield relative to the fall plow system, estimates of genotypic variance and heritability were similar for both tillage systems. This might depend on the base population being used; for the BS22(R)C1 S_1-lines there was a tendency toward a larger genotypic variance in no-till than fall plow, whereas for the BS13(SCT)C6 S_1-lines, genotypic variances tended to be equal in both tillage systems, or slightly smaller in no-till. Repeatability estimates for the commercial hybrids were in general similar for both tillage systems.

The correlations observed among traits in no-till were very similar to the correlations observed in fall plow. The same traits were associated with grain yield in both tillage systems. For the S_1-lines, the correlation between early vigor and grain yield in no-till was positive and significant for both populations, but the correlation coefficients were no larger in no-till than in fall plow. Correlations might have been somewhat different if thinning was not used.

No relative improvement in no-till yield was observed for the S_1-lines from BS13(SCT)C6, when compared to the S_1-lines from

BS22(R)C1. The percentage reduction and actual reduction of grain yield in no-till relative to fall plow was in fact greater for BS13(SCT)C6 than for BS22(R)C1. However, a comparison with lines from BS13(SCT)C0 would be necessary to evaluate the effect of cold tolerance selection upon no-till yield in BS13(SCT).

For the unselected S_1-lines, the data indicated that selection in no-till would identify a somewhat different set of lines than selection in fall plow. The data for the BS22(R)C1 S_1-lines were especially convincing. Only 40% of the lines for BS13(SCT)C6 were grown in both years, however, so the procedure involving selecting and evaluating in alternate years had only 40% as much weight as for the BS22(R)C1 lines. The data from the commercial hybrids provided no indication that the best no-till hybrids would be different than the best fall plow hybrids among available commercial hybrids.

The interaction of tillage with environments generally was larger than the effect of tillage alone. In 1981, the effect due to tillage systems on early vigor was large, yet in 1982 at Kanawha, only minor tillage induced effects were observed. The largest tillage induced effects on grain yield seemed to be associated with reduced early vigor in no-till, but other factors were also involved.

My conclusions for the study are that grain yield evaluation in no-till should be included in preliminary yield tests for genetic material whose future use might include no-till grain production. The genotype by tillage interaction does not appear to be so large as to require an entirely separate breeding program, but simultaneous evaluation in both tillage systems might identify a different set of genotypes than evaluation only in the fall plow system. I feel that breeders should accept a commitment to soil conservation, by attempting to develop genotypes which will provide farmers with comparable or better returns for no-till or reduce tillage maize production than for conventional tillage production using moldboard plows.

I also feel that the tremendous reduction in soil loss due to erosion which can be attributed to no-till should be sufficient justification for a more comprehensive commitment to making no-till or reduced tillage the standard procedure, and moldboard plowing the exception. It would appear that numerous research opportunities for cross-disciplinary study of the physical and physiological parameters of no-till remain, especially with regard to the genetic variability of the crop species. Studies of the interrelationship between the tillage system, the root system, and the above ground portions of the plant should be examined, in conjunction with assaying the genotypic variability, in order to gain a better understanding of how no-till yield barriers can be overcome. Farmers have demonstrated their ability to adapt to new tillage methods. Agricultural researchers should be leading the way in efforts to conserve soil, fossil fuels, and time, rather than merely responding to needs demonstrated by the farmers.

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APPENDIX

Entry-tillage means for traits discussed in this study are listed for each entry in each experiment. Means for Experiment 1 are listed in Tables A1 through A5, means for Experiment 2 are listed in Tables A6 through A10, and means for Experiment 3 are listed in Tables A11 through A15. The abbreviations used for the traits and their units are described in the Materials and Methods chapter. Entry names have been included. The listing was done by sets, and set means have been included.

TABLE A1. ENTRY-TILLAGE MEANS FOR EXPERIMENT 1, FOR GPMS, GPMSA, WPP, M, AND FST

SET# 1

EN	ENNAME	NT GPMS	FP GPMS	NT GPMSA	FP GPMSA	NT WPP	FP WPP	NT M	FP M	NT FST	FP FST
		G/M2	G/M2	G/M2	G/M2	G	G	%	%	#/PLT	#/PLT
1	S1-1	235	319	291	331	75.8	79.8	22.8	20.6	34.0	38.1
2	S1-2	273	359	272	363	56.0	73.3	23.0	22.9	42.1	42.1
3	S1-4	258	354	247	350	53.0	66.3	19.3	20.0	42.1	44.9
4	S1-5	299	324	282	314	57.8	59.9	20.2	19.5	42.9	45.4
5	S1-10	227	256	224	255	46.1	48.7	20.5	19.2	41.9	44.2
6	S1-32	399	409	381	411	76.7	82.5	22.5	21.7	43.9	42.8
7	S1-34	289	343	317	353	65.2	73.4	21.5	20.7	38.4	41.6
8	S1-35	331	415	319	410	64.6	77.5	21.8	20.8	43.6	45.2
9	S1-36	237	350	239	342	48.4	63.2	20.8	21.1	41.6	46.5
10	S1-37	271	326	259	324	54.5	62.2	20.2	20.7	42.8	45.5
11	S1-39	292	409	269	407	57.1	79.6	20.2	20.5	43.1	43.9
12	S1-42	235	268	232	273	49.2	58.5	19.7	20.2	41.9	42.4
13	S1-43	346	347	347	345	70.8	65.6	22.2	21.1	42.0	44.4
14	S1-45	245	323	286	333	66.1	70.0	21.6	21.4	35.7	40.4
15	S1-46	291	364	302	367	63.8	75.6	21.7	20.8	39.1	42.9
16	S1-47	362	359	358	354	72.5	68.8	20.9	20.6	42.1	44.0
17	S1-48	262	363	302	368	60.5	72.5	20.7	20.1	36.5	41.3
18	S1-49	370	412	395	421	88.8	93.7	24.3	21.4	37.7	40.4
19	S1-57	343	437	333	431	70.2	81.6	21.1	20.9	41.1	44.7
20	S1-58	342	336	333	335	69.1	65.2	21.1	21.5	41.5	43.9
	MEAN:	295	354	299	354	63.3	70.9	21.3	20.8	40.7	43.2

TABLE A1 (CONTINUED)

EN	ENNAME	NT GPMS	FP GPMS	NT GPMSA	FP GPMSA	NT WPP	FP WPP	NT M	FP M	NT FST	FP FST
		SET# 2									
		G/M2	G/M2	G/M2	G/M2	G	G	%	%	#/PLT	#/PLT
21	S1-59	331	374	313	365	64.9	66.6	22.2	22.5	43.5	47.0
22	S1-60	309	380	283	379	58.1	73.7	21.1	20.2	44.8	43.9
23	S1-199	498	460	473	457	92.8	86.9	23.5	22.7	45.2	44.7
24	S1-200	447	451	451	457	92.7	95.5	23.0	21.9	41.3	40.5
25	S1-204	268	331	274	332	60.5	73.7	20.5	20.9	39.5	39.3
26	S1-61	269	296	254	290	51.6	56.0	20.5	20.6	44.1	45.1
27	S1-62	381	403	370	399	74.8	75.3	21.6	21.3	43.4	45.3
28	S1-64	369	413	361	405	77.7	75.9	19.5	19.5	41.5	45.9
29	S1-66	342	381	316	378	65.1	79.3	21.9	21.4	44.5	41.2
30	S1-67	369	421	339	410	69.1	75.6	22.1	21.6	45.1	46.7
31	S1-70	286	343	299	355	62.6	71.4	20.8	20.6	39.6	40.5
32	S1-72	376	429	359	422	73.8	79.5	22.9	22.7	43.4	45.7
33	S1-73	317	396	284	399	58.0	79.7	22.4	22.4	45.9	43.6
34	S1-79	336	368	341	368	72.1	72.1	22.0	21.8	39.2	43.8
35	S1-80	488	508	482	508	94.2	98.5	21.9	21.3	43.4	43.9
36	S1-84	381	464	383	468	80.5	95.3	21.5	19.9	40.2	42.4
37	S1-104	388	412	386	414	76.1	83.5	22.2	21.2	41.4	42.2
38	S1-107	297	338	275	333	57.6	64.9	19.0	20.5	43.6	44.2
39	S1-113	273	351	312	363	69.6	87.0	24.6	23.2	36.5	36.8
40	S1-115	297	388	333	395	71.5	82.8	21.1	20.3	37.3	42.4
	MEAN:	351	395	344	395	71.2	78.7	21.7	21.3	42.2	43.3

TABLE A1 (CONTINUED)

SET# 3

EN	ENNAME	NT GPMS	FP GPMS	NT GPMSA	FP GPMSA	NT WPP	FP WPP	NT M	FP M	NT FST	FP FST
--	------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
		G/M2	G/M2	G/M2	G/M2	G	G	%	%	#/PLT	#/PLT
41	S1-116	263	277	322	297	81.0	89.1	21.2	20.9	33.3	35.5
42	S1-122	395	447	391	444	80.8	85.1	22.9	22.0	41.7	44.7
43	S1-123	311	343	327	346	68.9	68.4	21.8	20.9	39.7	43.2
44	S1-132	445	467	425	459	87.0	84.2	21.5	21.5	44.1	46.6
45	S1-136	303	390	319	398	69.0	86.6	22.9	21.9	38.3	40.6
46	S1-139	317	409	320	414	67.1	82.9	23.3	21.9	40.9	42.9
47	S1-151	349	417	355	424	76.1	84.6	23.7	22.0	40.3	42.5
48	S1-154	255	340	297	348	65.3	71.6	20.7	21.0	34.3	41.6
49	S1-155	278	352	281	356	60.0	69.7	19.6	19.5	40.7	44.9
50	S1-156	391	454	398	448	100.6	84.2	20.9	20.6	40.1	45.2
51	S1-160	329	415	332	411	70.2	81.2	21.9	21.2	39.9	43.7
52	S1-162	350	463	337	460	74.0	85.2	22.0	21.6	41.0	46.2
53	S1-163	352	434	357	435	74.9	84.8	22.6	21.9	41.2	43.3
54	S1-167	371	421	378	420	86.3	85.4	24.5	23.3	40.0	43.5
55	S1-168	279	396	294	393	62.4	76.6	22.5	20.7	38.0	43.6
56	S1-169	342	405	318	396	65.4	72.5	21.9	21.7	43.9	47.0
57	S1-176	293	387	309	383	65.7	72.8	22.0	20.5	38.3	44.9
58	S1-180	404	414	376	406	76.5	80.8	24.8	22.6	43.9	43.9
59	S1-182	360	510	363	510	77.8	100.3	21.5	21.4	40.5	44.1
60	S1-198	294	401	280	393	59.5	72.9	22.9	22.8	42.8	46.2
	MEAN:	334	407	339	407	73.4	80.9	22.3	21.5	40.1	43.7

TABLE A1 (CONTINUED)

SET# 4

EN	ENNAME	NT GPMS	FP GPMS	NT GPMSA	FP GPMSA	NT WPP	FP WPP	NT M	FP M	NT FST	FP FST
		G/M2	G/M2	G/M2	G/M2	G	G	%	%	#/PLT	#/PLT
61	S1-3	383	384	379	389	81.1	79.8	20.1	21.5	41.6	42.6
62	S1-6	361	335	346	342	69.9	72.2	22.5	21.3	44.3	40.7
63	S1-7	271	335	285	337	60.1	69.4	22.0	21.8	37.9	41.9
64	S1-11	279	338	289	336	57.6	64.4	20.5	19.9	40.0	44.5
65	S1-14	253	365	257	371	56.8	75.7	22.6	22.6	41.3	42.8
66	S1-16	284	364	280	354	63.2	64.2	21.2	20.4	41.0	47.6
67	S1-20	329	416	315	414	63.9	78.5	22.5	22.5	43.1	44.8
68	S1-22	333	362	348	364	74.5	73.9	22.7	21.4	39.9	41.2
69	S1-24	363	369	336	371	67.1	72.1	22.5	21.8	45.0	43.4
70	S1-26	218	241	240	250	50.5	54.7	22.7	21.7	38.0	39.4
71	S1-28	308	334	318	341	72.1	68.2	21.3	20.8	39.6	43.1
72	S1-31	362	448	368	457	82.8	97.0	22.8	22.7	39.7	41.0
73	S1-33	249	341	229	331	49.2	62.5	20.9	20.3	43.8	46.2
74	S1-38	354	363	335	359	70.1	68.5	22.3	20.6	42.1	44.6
75	S1-55	244	306	226	301	46.4	56.6	20.9	20.3	43.4	45.4
76	S1-201	401	441	381	432	76.1	79.9	20.7	21.0	44.7	46.0
77	S1-68	196	309	242	320	60.3	78.2	23.1	21.1	34.2	37.6
78	S1-71	404	463	385	465	79.2	94.5	23.1	21.8	43.8	41.8
79	S1-82	412	337	388	338	76.2	66.2	22.3	22.2	45.3	43.8
80	S1-83	375	459	426	463	97.5	95.1	23.0	22.1	34.5	41.7
	MEAN:	319	365	319	367	67.7	73.6	22.0	21.4	41.2	43.0

TABLE A1 (CONTINUED)

SET# 5

EN	ENNAME		NT GPMS	FP GPMS	NT GPMSA	FP GPMSA	NT WPP	FP WPP	NT M	FP M	NT FST	FP FST
--	------		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
			G/M2	G/M2	G/M2	G/M2	G	G	%	%	#/PLT	#/PLT
81	S1-87		314	400	301	396	61.9	73.9	20.5	20.8	42.6	45.7
82	S1-90		347	494	364	489	84.9	95.1	21.4	22.4	38.4	43.9
83	S1-99		321	398	328	394	72.8	76.2	22.3	21.6	39.8	44.2
84	S1-103		301	356	296	351	61.9	65.7	21.0	20.9	42.4	45.7
85	S1-127		218	293	268	305	59.8	71.1	23.2	22.1	34.6	38.1
86	S1-130		328	400	338	401	71.9	79.3	21.7	21.7	40.0	43.5
87	S1-141		330	345	330	351	68.2	71.8	20.6	20.5	41.9	42.5
88	S1-143		383	497	356	494	72.1	92.8	21.6	21.6	44.4	45.5
89	S1-146		341	402	344	401	72.4	76.9	21.0	22.2	39.7	44.9
90	S1-156		323	403	377	420	96.4	100.8	19.8	20.3	33.0	36.8
91	S1-153		322	376	310	375	69.2	74.0	22.5	22.4	41.1	44.0
92	S1-157		418	438	394	432	81.0	80.9	24.1	22.8	43.8	45.7
93	S1-158		344	476	345	468	71.9	88.1	22.0	21.7	40.9	45.6
94	S1-165		256	340	220	330	46.1	63.2	20.4	20.1	46.5	45.9
95	S1-172		315	378	307	378	70.3	75.5	21.1	22.0	40.0	43.5
96	S1-185		297	385	281	387	57.7	75.6	19.0	19.2	44.2	43.8
97	S1-189		400	428	378	420	76.3	79.4	22.1	22.4	44.0	45.1
98	S1-190		478	484	458	476	90.8	88.7	22.9	22.8	44.4	45.9
99	S1-196		299	367	276	358	57.3	68.0	23.4	23.2	44.7	45.4
100	S1-197		245	323	268	328	57.2	64.5	19.6	20.5	38.5	42.2
		MEAN:	329	399	327	398	70.0	78.1	21.5	21.6	41.2	43.9

TABLE A2. ENTRY-TILLAGE MEANS FOR EXPERIMENT 1, FOR PSL, PRL, PDE, PHT, EHT, AND SG

SET# 1

EN	ENNAME		NT PSL	FP PSL	NT PRL	FP PRL	NT PDE	FP PDE	NT PHT	FP PHT	NT EHT	FP EHT	NT SG	FP SG
			%	%	%	%	%	%	CM	CM	CM	CM	1-9	1-9
1	S1-1		9.4	10.6	1.1	2.5	0.2	0.4	135	145	51	56	4.9	3.8
2	S1-2		31.5	26.8	0.0	0.0	0.0	0.0	136	144	50	54	3.5	4.0
3	S1-4		9.1	10.4	0.0	1.4	0.2	0.7	124	139	42	52	2.6	2.6
4	S1-5		12.0	18.5	0.2	0.0	0.0	0.0	131	135	42	48	4.6	2.4
5	S1-10		11.5	18.0	0.5	1.1	0.0	0.0	123	130	38	41	2.2	2.4
6	S1-32		17.7	16.1	0.2	0.8	0.0	0.0	157	162	62	67	6.0	4.9
7	S1-34		38.0	29.2	0.2	0.0	0.0	0.2	144	144	63	66	3.7	3.4
8	S1-35		15.0	18.7	0.0	0.6	0.0	0.0	155	157	53	57	3.9	3.3
9	S1-36		17.5	13.8	0.4	0.0	0.3	0.0	133	142	39	47	3.6	4.2
10	S1-37		18.5	17.4	0.3	4.7	0.0	0.0	139	142	47	51	3.9	3.8
11	S1-39		11.8	8.7	0.4	4.5	0.0	0.0	143	152	45	50	2.4	3.2
12	S1-42		15.7	16.8	0.7	2.4	0.0	0.0	128	137	46	52	2.3	2.5
13	S1-43		14.1	16.5	0.0	3.1	0.0	0.4	156	157	56	61	4.2	3.5
14	S1-45		14.0	33.0	0.0	0.2	0.0	0.0	138	146	47	54	3.1	2.7
15	S1-46		9.1	11.0	1.3	1.3	0.0	0.0	133	139	45	49	2.7	3.0
16	S1-47		14.8	18.3	0.2	0.0	0.6	1.1	145	146	50	51	3.8	3.8
17	S1-48		24.0	17.4	0.4	1.8	0.2	0.4	139	143	46	48	5.2	3.9
18	S1-49		19.7	13.4	0.0	0.2	0.0	0.6	143	147	53	55	5.1	5.1
19	S1-57		13.3	16.1	1.6	2.4	0.0	0.0	148	151	54	59	4.4	3.9
20	S1-58		14.1	18.6	1.2	1.0	0.0	0.0	144	145	47	48	5.3	4.0
		MEAN:	16.5	17.5	0.4	1.4	0.1	0.2	140	145	49	53	3.9	3.5

TABLE A2 (CONTINUED)

SET# 2

EN	ENNAME	NT PSL	FP PSL	NT PRL	FP PRL	NT PDE	FP PDE	NT PHT	FP PHT	NT EHT	FP EHT	NT SG	FP SG
		%	%	%	%	%	%	CM	CM	CM	CM	1-9	1-9
21	S1-59	12.4	18.0	0.0	0.4	0.0	0.2	139	146	46	50	4.7	4.6
22	S1-60	4.9	15.9	0.2	0.9	0.4	0.2	132	142	43	49	5.4	4.9
23	S1-199	7.5	12.1	1.5	3.9	0.0	0.4	145	147	54	58	4.8	4.8
24	S1-200	13.8	18.6	0.0	1.3	0.7	0.2	170	168	68	72	5.3	4.2
25	S1-204	14.7	14.9	0.0	0.9	0.2	0.0	139	151	50	55	3.3	4.8
26	S1-61	16.8	20.5	0.6	0.7	0.5	0.0	138	146	50	57	2.3	2.8
27	S1-62	23.0	18.0	0.3	0.4	0.0	0.7	143	142	57	56	4.5	4.7
28	S1-64	13.2	20.2	0.2	3.8	0.0	0.2	145	151	55	58	2.9	3.5
29	S1-66	14.4	15.7	2.4	0.0	0.2	0.2	138	138	54	54	3.4	3.3
30	S1-67	17.1	17.6	0.0	0.7	0.0	0.0	173	170	62	63	4.8	4.0
31	S1-70	11.4	16.4	0.9	0.0	0.0	0.0	152	151	59	58	5.9	4.7
32	S1-72	12.2	14.0	1.8	1.6	0.8	0.2	144	147	52	53	4.9	4.4
33	S1-73	12.5	12.4	0.5	2.0	0.5	0.0	155	160	59	63	5.9	6.2
34	S1-79	10.3	13.8	0.0	0.5	0.0	0.0	138	137	49	49	5.6	4.8
35	S1-80	8.1	16.1	1.6	4.7	0.0	0.2	164	162	59	61	5.4	5.1
36	S1-84	4.4	8.0	0.2	1.8	0.0	0.0	143	150	51	57	3.6	4.1
37	S1-104	32.6	31.2	1.9	1.3	0.0	0.0	164	162	71	66	5.9	5.3
38	S1-107	9.4	14.3	0.0	0.2	0.4	0.5	140	143	47	47	4.6	4.1
39	S1-113	20.6	23.1	0.8	0.8	0.2	0.0	145	147	60	61	3.7	3.7
40	S1-115	13.4	17.4	0.0	1.1	0.0	0.0	138	144	47	53	3.6	3.3
	MEAN:	13.6	16.9	0.6	1.4	0.2	0.2	147	150	55	57	4.5	4.4

TABLE A2 (CONTINUED)

SET# 3

EN	ENNAME	NT PSL	FP PSL	NT PRL	FP PRL	NT PDE	FP PDE	NT PHT	FP PHT	NT EHT	FP EHT	NT SG	FP SG
--	------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
		%	%	%	%	%	%	CM	CM	CM	CM	1-9	1-9
41	S1-116	34.2	29.7	0.0	0.0	0.4	0.6	170	170	70	73	5.1	4.9
42	S1-122	9.1	7.3	0.9	2.4	0.0	0.5	150	157	57	61	5.5	4.4
43	S1-123	20.5	20.4	1.0	0.2	0.0	0.8	155	159	62	63	2.1	3.3
44	S1-132	21.1	11.4	0.0	3.0	0.0	0.0	165	171	64	69	4.7	5.0
45	S1-136	8.8	15.9	1.4	0.4	0.2	0.2	136	147	50	57	4.1	4.2
46	S1-139	7.5	13.6	0.6	3.4	0.0	0.0	150	154	55	60	5.4	5.1
47	S1-151	12.6	18.5	0.6	1.3	0.0	0.2	153	159	53	58	4.4	4.1
48	S1-154	3.7	9.9	0.0	0.2	0.0	0.2	118	132	37	46	3.4	4.1
49	S1-155	17.9	20.2	1.9	0.4	0.0	0.0	148	153	54	59	2.5	3.3
50	S1-156	13.3	16.3	0.7	0.9	0.2	0.0	152	160	52	61	5.8	6.0
51	S1-160	26.6	17.3	0.5	2.4	0.0	0.0	152	166	54	63	4.8	4.3
52	S1-162	20.7	18.0	0.6	1.5	0.0	0.0	160	168	64	69	6.0	5.3
53	S1-163	20.5	11.0	0.0	0.5	0.4	0.0	154	154	59	62	6.2	6.2
54	S1-167	12.3	19.3	0.0	2.2	0.0	0.8	152	160	58	64	6.5	5.6
55	S1-168	14.7	20.9	0.0	1.5	0.7	0.5	155	155	64	66	4.4	3.0
56	S1-169	16.6	18.5	0.0	0.0	0.4	0.0	132	143	43	51	3.6	3.2
57	S1-176	16.8	18.0	0.0	0.0	0.3	0.0	141	150	47	56	3.7	3.6
58	S1-180	26.0	22.1	0.2	0.2	0.5	0.5	164	164	65	65	7.2	6.4
59	S1-182	9.4	15.4	0.0	0.9	0.2	0.0	153	163	52	61	5.1	4.6
60	S1-198	5.1	15.9	0.6	3.0	0.0	0.2	130	152	48	58	4.9	4.7
	MEAN:	15.9	17.0	0.5	1.2	0.2	0.2	149	157	55	61	4.8	4.6

TABLE A2 (CONTINUED)

SET# 4

EN	ENNAME	NT PSL	FP PSL	NT PRL	FP PRL	NT PDE	FP PDE	NT PHT	FP PHT	NT EHT	FP EHT	NT SG	FP SG
		%	%	%	%	%	%	CM	CM	CM	CM	1-9	1-9
61	S1-3	7.6	18.8	0.2	0.0	0.3	0.8	137	139	53	55	4.9	4.6
62	S1-6	16.5	21.2	0.7	3.1	0.4	0.0	135	145	51	59	3.8	3.0
63	S1-7	8.3	16.6	1.0	0.6	0.0	0.5	131	144	39	49	3.8	3.8
64	S1-11	13.9	18.4	0.7	0.9	0.0	0.2	131	133	49	50	3.6	3.6
65	S1-14	11.8	13.5	0.2	3.6	0.2	0.2	145	156	44	53	4.2	4.8
66	S1-16	11.1	15.2	0.3	0.6	0.5	0.2	140	144	45	50	4.8	4.7
67	S1-20	20.9	23.1	0.0	0.3	1.2	0.5	144	150	53	58	5.8	5.3
68	S1-22	5.9	15.5	0.5	0.3	0.3	0.0	141	148	49	52	4.6	4.3
69	S1-24	19.5	17.0	0.2	0.6	0.2	0.0	156	154	61	61	5.3	4.5
70	S1-26	9.9	16.0	1.5	1.2	0.0	0.0	127	131	42	43	4.3	3.7
71	S1-28	18.3	18.3	0.0	0.4	0.9	0.4	132	143	50	55	4.2	3.9
72	S1-31	12.4	20.0	0.3	0.0	0.5	1.2	147	152	48	54	4.2	3.9
73	S1-33	41.7	33.8	0.0	1.2	0.0	0.0	140	145	57	60	3.4	3.7
74	S1-38	11.2	8.3	0.5	0.0	0.0	0.2	147	146	46	48	4.4	3.2
75	S1-55	15.2	19.7	0.2	1.4	0.0	0.0	139	147	49	55	3.0	2.9
76	S1-201	16.3	20.1	2.8	1.1	0.0	0.0	149	153	57	64	5.3	4.5
77	S1-68	12.2	18.3	0.4	0.7	0.0	0.4	133	140	50	57	3.3	3.3
78	S1-71	20.4	21.0	0.9	1.8	0.2	0.4	153	159	69	71	5.6	4.6
79	S1-82	2.5	9.1	0.6	0.0	0.0	0.2	140	147	44	47	6.4	4.6
80	S1-83	8.9	12.2	0.9	5.3	0.0	0.0	163	158	60	57	6.7	5.7
	MEAN:	14.2	17.8	0.6	1.2	0.2	0.3	142	147	51	55	4.6	4.1

TABLE A2 (CONTINUED)

EN	ENNAME	SET# 5 NT PSL	FP PSL	NT PRL	FP PRL	NT PDE	FP PDE	NT PHT	FP PHT	NT EHT	FP EHT	NT SG	FP SG
--	------	%	%	%	%	%	%	CM	CM	CM	CM	1-9	1-9
81	S1-87	24.5	17.4	1.3	0.6	0.0	0.2	146	151	50	54	2.1	3.1
82	S1-90	11.0	16.7	1.5	0.2	0.0	0.2	147	160	53	64	3.6	4.0
83	S1-99	22.3	26.1	1.6	1.8	0.2	0.5	151	156	60	65	4.5	3.5
84	S1-103	13.9	11.9	2.8	1.3	0.0	0.2	146	156	55	63	2.8	3.5
85	S1-127	17.7	20.7	0.8	0.9	0.2	0.0	142	149	53	58	5.1	5.1
86	S1-130	23.0	19.4	0.7	0.7	0.0	0.0	158	156	68	70	5.4	4.3
87	S1-141	12.6	20.0	0.0	1.2	1.5	0.4	147	146	54	58	3.9	3.7
88	S1-143	12.0	14.6	5.6	2.6	0.0	0.4	151	154	64	68	4.9	5.2
89	S1-146	16.7	21.7	1.4	0.0	0.7	0.0	146	150	54	60	4.5	5.2
90	S1-156	9.0	17.6	2.0	1.1	0.2	0.0	154	163	53	59	5.9	4.9
91	S1-153	12.8	8.2	0.0	0.4	0.2	0.2	143	148	51	56	4.9	4.5
92	S1-157	12.9	14.0	0.0	0.2	0.2	0.2	159	159	70	74	7.3	6.2
93	S1-158	13.5	19.6	3.3	3.1	0.2	0.2	146	152	61	66	4.3	4.4
94	S1-165	22.8	19.5	7.9	0.4	0.0	0.2	151	159	60	65	2.4	3.4
95	S1-172	14.1	20.8	1.8	2.2	0.3	1.6	144	151	50	55	3.8	4.1
96	S1-185	14.0	14.3	0.6	1.0	0.2	0.4	131	145	53	61	3.1	3.8
97	S1-189	14.7	13.8	0.7	0.2	0.0	0.0	149	153	60	64	4.5	4.9
98	S1-190	14.1	7.6	0.2	0.9	0.5	0.0	161	163	70	71	6.0	5.8
99	S1-196	16.6	20.3	0.7	2.6	0.3	0.0	152	159	51	58	4.5	4.6
100	S1-197	16.3	11.2	1.3	1.5	0.0	0.0	150	156	51	59	4.1	5.2
	MEAN:	15.7	16.8	1.7	1.1	0.2	0.2	149	154	57	62	4.4	4.5

TABLE A3. ENTRY-TILLAGE MEANS FOR EXPERIMENT 1, FOR PEM, EV, EMI, EPHT, AND BMPP

SET# 1

EN	ENNAME	NT PEM	FP PEM	NT EV	FP EV	NT EMI	FP EMI	NT EPHT	FP EPHT	NT BMPP	FP BMPP
		%	%	1-9	1-9	DAYS	DAYS	CM	CM	CM	CM
1	S1-1	65.7	65.9	3.7	5.3	23.3	16.5	16.9	28.1	102	158
2	S1-2	76.3	75.6	4.5	5.6	23.0	17.6	19.2	22.4	143	161
3	S1-4	73.9	81.2	4.7	6.2	21.1	17.0	18.1	26.6	129	201
4	S1-5	70.4	87.8	4.4	6.2	19.4	17.7	19.8	25.5	135	217
5	S1-10	65.4	76.9	4.3	5.7	20.6	16.8	17.7	24.3	112	174
6	S1-32	74.6	81.5	4.6	6.2	20.3	18.3	17.4	24.4	126	188
7	S1-34	65.8	76.5	4.2	5.4	20.9	18.1	18.5	23.9	120	172
8	S1-35	75.7	85.5	4.4	6.1	19.7	18.0	17.0	24.3	125	204
9	S1-36	73.8	88.4	4.1	6.1	21.4	18.2	17.0	23.8	125	207
10	S1-37	75.2	80.3	4.8	5.7	21.2	17.8	18.5	23.7	137	183
11	S1-39	73.8	78.6	4.7	6.4	21.4	17.9	18.2	26.2	129	198
12	S1-42	70.6	81.2	4.8	6.4	19.6	18.4	20.0	26.1	136	203
13	S1-43	65.9	78.3	3.8	5.2	19.9	17.0	18.1	25.2	114	187
14	S1-45	63.4	69.7	3.8	5.2	23.5	18.2	18.9	24.1	114	154
15	S1-46	65.6	75.3	3.8	5.0	21.2	17.3	15.3	21.6	97	150
16	S1-47	75.5	82.7	5.1	6.1	20.3	18.7	19.3	22.6	143	179
17	S1-48	61.5	74.3	3.9	5.6	20.7	19.6	18.5	23.0	107	162
18	S1-49	64.8	74.3	4.4	5.9	20.1	17.4	17.7	24.0	105	164
19	S1-57	66.2	81.4	3.8	6.1	20.0	17.4	17.7	24.9	115	195
20	S1-58	72.3	79.6	4.3	6.1	22.7	16.4	18.7	27.0	133	208
	MEAN:	69.8	78.8	4.3	5.8	21.0	17.7	18.1	24.6	122	183

TABLE A3 (CONTINUED)

SET# 2

EN	ENNAME	NT PEM	FP PEM	NT EV	FP EV	NT EMI	FP EMI	NT EPHT	FP EPHT	NT BMPP	FP BMPP
--	------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
		%	%	1-9	1-9	DAYS	DAYS	CM	CM	CM	CM
21	S1-59	83.8	86.2	5.3	6.4	21.3	18.5	20.5	24.3	171	206
22	S1-60	78.4	80.6	5.4	5.5	19.1	15.9	20.5	25.0	160	198
23	S1-199	79.4	83.9	5.1	5.7	21.7	18.0	19.8	24.0	155	194
24	S1-200	70.7	73.0	5.1	5.4	19.2	17.1	20.5	24.1	146	169
25	S1-204	72.2	70.0	5.0	5.1	18.2	18.2	20.1	21.8	149	152
26	S1-61	75.5	80.6	4.8	4.7	20.2	19.0	21.4	21.5	158	171
27	S1-62	75.2	80.7	4.4	5.5	21.8	18.4	19.7	23.7	146	183
28	S1-64	73.6	86.1	5.3	6.1	21.3	17.1	21.4	24.0	156	203
29	S1-66	79.4	77.8	4.8	5.8	21.3	16.9	20.5	23.8	160	178
30	S1-67	76.3	82.9	5.0	5.8	20.8	17.4	19.2	24.3	143	194
31	S1-70	74.2	75.1	4.1	5.1	21.1	18.6	17.8	22.3	131	153
32	S1-72	75.1	77.7	5.0	5.4	19.5	17.5	19.8	23.9	147	183
33	S1-73	73.3	79.6	5.4	5.9	19.6	17.6	20.5	22.7	148	173
34	S1-79	66.5	71.5	4.5	5.4	22.1	18.3	19.8	21.3	130	147
35	S1-80	76.7	78.7	5.2	5.4	22.6	18.5	21.4	24.0	165	186
36	S1-84	70.5	70.7	5.1	5.3	19.5	15.9	20.2	23.3	144	157
37	S1-104	66.1	69.8	5.3	5.4	21.1	19.1	19.4	21.6	130	149
38	S1-107	82.0	82.0	4.7	5.6	20.6	18.7	18.9	22.1	155	178
39	S1-113	54.6	67.0	3.4	4.7	21.6	20.8	16.9	19.7	88	125
40	S1-115	70.1	77.3	3.9	4.9	20.8	18.5	17.6	21.3	120	155
	MEAN:	73.7	77.6	4.8	5.5	20.7	18.0	19.8	22.9	145	173

TABLE A3 (CONTINUED)

SET# 3

EN	ENNAME		NT PEM	FP PEM	NT EV	FP EV	NT EMI	FP EMI	NT EPHT	FP EPHT	NT BMPP	FP BMPP
--	------		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
			%	%	1-9	1-9	DAYS	DAYS	CM	CM	CM	CM
41	S1-116		57.2	61.9	3.9	4.3	25.4	22.5	18.5	21.7	103	120
42	S1-122		72.7	81.0	5.5	6.6	19.9	17.0	22.3	25.8	158	199
43	S1-123		66.6	75.5	4.5	5.8	20.2	17.2	18.4	25.4	121	181
44	S1-132		76.7	85.1	4.8	5.8	20.4	16.9	21.1	25.4	157	213
45	S1-136		68.5	71.3	4.7	5.2	20.7	18.5	18.2	23.8	117	152
46	S1-139		65.4	77.3	3.5	5.2	22.5	17.5	15.6	20.4	100	146
47	S1-151		66.0	79.5	4.3	5.9	21.6	18.0	16.8	22.1	114	165
48	S1-154		54.3	71.6	3.9	5.4	21.9	18.1	16.6	22.0	84	143
49	S1-155		72.7	78.3	4.4	5.3	20.7	17.6	18.6	23.2	129	167
50	S1-156		64.4	81.7	4.4	6.1	20.2	18.7	19.8	24.6	128	194
51	S1-160		66.1	79.1	3.8	5.6	20.9	16.6	17.5	25.0	112	185
52	S1-162		66.0	82.8	4.7	6.5	19.5	17.6	17.8	25.0	115	201
53	S1-163		74.6	77.6	4.4	5.6	21.9	18.7	16.8	21.8	122	163
54	S1-167		69.7	81.1	3.8	5.7	22.2	18.4	16.5	24.2	108	181
55	S1-168		63.2	78.1	4.4	6.2	21.4	18.7	17.2	24.0	106	176
56	S1-169		77.9	86.7	4.4	6.4	19.0	17.1	16.9	23.7	130	197
57	S1-176		62.8	79.4	4.5	6.1	23.3	17.3	17.2	22.1	107	172
58	S1-180		75.0	74.4	4.3	5.6	22.1	18.0	17.4	22.0	128	158
59	S1-182		69.3	85.7	5.0	6.7	19.9	17.5	19.7	27.0	131	218
60	S1-198		73.0	83.7	4.2	5.7	20.1	18.4	17.8	21.7	127	177
		MEAN:	68.1	78.6	4.4	5.8	21.2	18.0	18.0	23.5	120	175

TABLE A3 (CONTINUED)

SET# 4

EN	ENNAME	NT PEM	FP PEM	NT EV	FP EV	NT EMI	FP EMI	NT EPHT	FP EPHT	NT BMPP	FP BMPP
--	------	%	%	1-9	1-9	DAYS	DAYS	CM	CM	CM	CM
61	S1-3	64.1	77.4	5.0	5.7	22.2	19.2	18.7	21.6	115	156
62	S1-6	78.9	76.9	5.1	5.9	20.2	17.0	19.0	23.8	144	172
63	S1-7	69.6	75.6	3.8	5.4	23.4	18.1	16.3	20.7	110	146
64	S1-11	70.0	80.8	4.7	6.3	22.9	18.1	17.5	21.8	120	173
65	S1-14	72.2	78.1	4.5	5.3	24.2	17.4	17.7	22.2	124	165
66	S1-16	64.7	81.3	3.4	5.5	19.5	14.6	14.9	21.3	95	166
67	S1-20	70.5	80.5	4.1	5.6	19.8	17.6	16.1	20.0	112	155
68	S1-22	70.4	77.0	3.9	5.2	22.2	18.9	17.2	21.8	115	161
69	S1-24	79.2	80.1	5.0	5.4	22.1	17.5	20.7	23.0	163	175
70	S1-26	69.3	68.9	4.4	4.7	21.6	20.2	17.8	20.4	118	129
71	S1-28	71.9	76.2	4.3	4.8	21.7	18.8	17.6	20.7	125	148
72	S1-31	63.8	67.0	3.8	5.2	21.2	16.7	17.8	21.0	112	134
73	S1-33	76.4	84.8	4.9	5.8	20.3	16.7	18.9	20.8	143	170
74	S1-38	78.6	78.4	4.3	5.4	22.7	17.7	17.2	21.8	134	165
75	S1-55	73.1	85.6	4.3	6.2	19.0	16.7	18.3	22.3	132	188
76	S1-201	71.6	81.0	4.2	6.3	21.0	16.0	19.9	25.2	138	197
77	S1-68	64.1	72.2	4.0	5.2	23.8	20.4	18.6	25.2	116	165
78	S1-71	75.2	79.0	5.2	5.6	22.6	19.3	19.9	24.3	148	182
79	S1-82	77.5	80.9	4.6	5.3	20.2	17.5	18.9	21.0	144	164
80	S1-83	59.0	75.2	4.0	5.7	23.3	19.2	18.7	24.2	103	166
	MEAN:	71.0	77.9	4.4	5.5	21.7	17.9	18.1	22.2	126	164

TABLE A3 (CONTINUED)

SET# 5

EN	ENNAME	NT PEM	FP PEM	NT EV	FP EV	NT EMI	FP EMI	NT EPHT	FP EPHT	NT BMPP	FP BMPP
--	------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
		%	%	1-9	1-9	DAYS	DAYS	CM	CM	CM	CM
81	S1-87	73.0	82.6	4.8	5.5	18.8	18.7	19.8	26.1	143	207
82	S1-90	70.9	80.5	4.8	6.1	20.5	17.7	18.7	25.3	131	193
83	S1-99	75.3	80.8	4.5	5.8	20.6	17.1	19.0	23.7	137	183
84	S1-103	77.4	78.5	5.1	6.2	20.8	17.0	20.0	27.0	148	201
85	S1-127	61.9	64.7	3.5	5.3	18.0	18.2	16.5	23.3	100	135
86	S1-130	70.3	78.3	3.7	5.5	20.6	17.9	18.5	25.4	121	186
87	S1-141	74.3	81.7	5.2	5.8	20.9	18.7	19.8	25.2	144	194
88	S1-143	77.6	82.2	4.8	6.3	19.6	16.9	19.8	26.1	151	206
89	S1-146	66.1	80.4	4.8	6.0	21.2	18.7	20.5	27.0	133	208
90	S1-156	61.9	60.6	3.3	5.0	23.7	17.4	19.1	26.2	118	143
91	S1-153	68.5	78.4	4.8	5.6	21.2	17.1	18.5	23.9	125	179
92	S1-157	70.2	77.2	4.1	5.7	20.5	16.1	21.3	27.4	148	200
93	S1-158	78.2	83.7	4.0	5.9	20.6	16.7	17.8	24.9	137	200
94	S1-165	82.1	85.1	5.0	5.4	19.2	15.8	22.0	25.3	177	212
95	S1-172	65.9	78.9	4.9	6.3	18.8	17.0	20.0	28.1	127	208
96	S1-185	79.4	84.8	4.6	5.3	19.2	17.7	20.6	27.9	158	219
97	S1-189	71.3	81.4	4.8	6.3	17.6	16.7	20.6	26.5	145	213
98	S1-190	76.9	85.0	5.3	6.3	19.0	17.4	21.4	26.7	162	219
99	S1-196	76.1	83.5	4.8	5.2	17.2	17.4	19.5	23.6	144	190
100	S1-197	59.6	70.6	4.0	5.6	20.1	18.3	20.6	26.7	117	170
	MEAN:	71.8	78.9	4.5	5.8	19.9	17.4	19.7	25.8	138	193

TABLE A4. ENTRY-TILLAGE MEANS FOR EXPERIMENT 1, FOR PS2, SK2, PI, SKI, AND PSKI

SET# 1

EN	ENNAME		NT PS2	FP PS2	NT SK2	FP SK2	NT PI	FP PI	NT SKI	FP SKI	NT PSKI	FP PSKI
			DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS
1	S1-1		85.8	82.0	88.4	84.3	3.6	4.1	3.6	4.3	2.6	2.3
2	S1-2		85.8	83.3	88.5	86.1	4.3	4.5	4.4	4.3	2.8	2.9
3	S1-4		84.5	82.1	87.4	84.5	3.9	4.0	4.6	4.5	2.9	2.4
4	S1-5		84.8	81.4	88.0	84.4	4.1	4.8	4.8	5.4	3.3	3.0
5	S1-10		83.9	80.5	86.4	83.4	4.6	5.1	3.9	5.0	2.5	2.9
6	S1-32		87.4	83.9	90.0	87.4	5.0	4.9	4.8	4.8	2.6	3.5
7	S1-34		87.4	83.4	90.3	86.3	4.6	4.3	5.3	3.8	2.9	2.9
8	S1-35		87.1	83.8	89.9	86.3	3.9	4.1	4.6	4.0	2.8	2.5
9	S1-36		86.4	82.1	88.3	84.5	4.8	4.1	4.9	5.0	1.9	2.4
10	S1-37		85.9	83.1	88.0	84.6	5.0	4.4	5.5	5.0	2.1	1.5
11	S1-39		86.5	83.5	89.5	85.3	3.5	4.4	5.5	4.3	3.0	1.8
12	S1-42		84.3	82.1	87.4	84.6	5.0	4.8	4.4	4.4	3.1	2.5
13	S1-43		86.4	84.1	88.4	85.9	3.8	4.3	4.3	4.6	2.0	1.8
14	S1-45		86.1	82.9	88.4	85.9	3.1	4.5	5.0	4.6	2.3	3.0
15	S1-46		88.0	84.1	91.0	86.6	4.4	3.5	4.9	5.1	3.0	2.5
16	S1-47		84.6	83.3	88.0	86.1	3.9	5.0	4.0	4.9	3.4	2.9
17	S1-48		86.3	82.3	88.5	84.4	4.6	4.6	4.4	3.9	2.3	2.1
18	S1-49		86.9	82.6	88.5	84.3	4.5	4.8	5.4	3.8	1.6	1.6
19	S1-57		86.9	82.3	88.8	84.3	4.4	4.8	4.9	4.0	1.9	2.0
20	S1-58		85.9	82.1	88.0	85.0	4.0	4.5	4.4	4.9	2.1	2.9
		MEAN:	86.0	82.7	88.6	85.2	4.2	4.5	4.7	4.5	2.5	2.5

TABLE A4 (CONTINUED)

SET# 2

EN	ENNAME	NT PS2 DAYS	FP PS2 DAYS	NT SK2 DAYS	FP SK2 DAYS	NT PI DAYS	FP PI DAYS	NT SKI DAYS	FP SKI DAYS	NT PSKI DAYS	FP PSKI DAYS
21	S1-59	83.8	82.4	86.8	84.9	4.6	5.1	5.0	4.5	3.0	2.5
22	S1-60	84.1	83.4	87.4	86.0	3.3	4.4	5.8	4.3	3.3	2.6
23	S1-199	85.6	83.5	88.1	86.6	3.5	3.3	6.0	4.8	2.5	3.1
24	S1-200	87.5	84.4	90.0	86.5	5.5	4.0	6.1	3.9	2.5	2.1
25	S1-204	85.5	83.4	88.5	87.1	6.1	4.0	4.9	4.6	3.0	3.8
26	S1-61	84.3	84.1	87.3	87.1	3.8	3.4	4.3	5.8	3.0	3.0
27	S1-62	86.8	84.8	90.1	88.0	5.3	4.0	5.9	3.8	3.4	3.3
28	S1-64	85.4	83.8	87.5	86.3	5.1	4.1	4.5	4.0	2.1	2.5
29	S1-66	85.0	84.0	87.0	87.3	4.5	4.3	4.9	5.8	2.0	3.3
30	S1-67	88.5	85.9	91.5	88.5	4.4	3.9	5.9	4.1	3.0	2.6
31	S1-70	86.5	85.5	90.3	88.8	4.3	4.3	4.5	4.4	3.8	3.3
32	S1-72	86.0	84.3	89.9	88.0	5.0	4.5	5.3	4.3	3.9	3.8
33	S1-73	86.5	86.1	89.1	88.5	4.0	4.9	4.3	4.8	2.6	2.4
34	S1-79	87.6	84.9	90.8	88.1	5.4	3.8	6.0	3.6	3.1	3.3
35	S1-80	87.4	85.3	89.4	86.3	4.3	4.1	5.5	4.1	2.0	1.0
36	S1-84	84.1	82.9	87.3	85.6	4.6	3.9	4.1	4.1	3.1	2.8
37	S1-104	88.1	86.4	90.8	88.6	4.9	3.0	4.5	3.9	2.6	2.3
38	S1-107	85.1	82.6	86.6	85.0	4.4	4.0	4.0	3.8	1.5	2.4
39	S1-113	88.9	86.9	90.6	89.4	4.3	5.0	3.9	5.0	1.8	2.5
40	S1-115	86.4	84.0	88.4	86.8	4.3	4.3	4.4	4.0	2.0	2.8
	MEAN:	86.1	84.4	88.9	87.2	4.6	4.1	5.0	4.4	2.7	2.8

TABLE A4 (CONTINUED)

EN	ENNAME		SET# 3 NT PS2 DAYS	FP PS2 DAYS	NT SK2 DAYS	FP SK2 DAYS	NT PI DAYS	FP PI DAYS	NT SKI DAYS	FP SKI DAYS	NT PSKI DAYS	FP PSKI DAYS
41	S1-116		90.0	86.3	91.9	87.4	5.4	4.1	4.9	3.8	1.9	1.1
42	S1-122		85.9	83.3	88.0	87.6	4.4	3.6	4.4	4.9	2.1	4.4
43	S1-123		87.3	85.0	89.4	87.6	4.1	3.8	3.5	4.4	2.1	2.6
44	S1-132		87.3	84.5	89.3	87.3	4.8	4.3	4.9	4.9	2.0	2.8
45	S1-136		86.1	85.6	88.5	87.0	3.9	4.3	4.5	4.6	2.4	1.4
46	S1-139		90.3	86.4	92.1	88.6	6.0	4.5	4.6	4.1	1.9	2.3
47	S1-151		88.3	84.6	91.3	86.9	4.1	4.1	5.6	4.6	3.0	2.3
48	S1-154		86.0	83.3	88.4	85.6	4.4	4.4	4.6	4.8	2.4	2.4
49	S1-155		86.3	85.0	88.3	86.6	4.6	4.4	5.1	4.4	2.0	1.6
50	S1-156		87.6	85.5	89.6	88.4	4.1	3.3	5.0	4.3	2.0	2.9
51	S1-160		88.6	85.8	90.6	87.8	5.4	4.0	5.9	3.9	2.0	2.0
52	S1-162		88.8	85.1	91.1	87.1	4.4	4.0	4.6	3.9	2.4	2.0
53	S1-163		89.0	86.1	92.1	88.9	3.8	4.1	5.0	4.0	3.1	2.8
54	S1-167		88.6	85.9	91.6	87.0	4.3	3.5	4.8	3.3	3.0	1.1
55	S1-168		90.1	86.1	92.6	87.5	4.8	3.9	6.9	3.6	2.5	1.4
56	S1-169		86.0	84.3	88.5	86.3	4.1	3.9	4.5	3.6	2.5	2.0
57	S1-176		87.0	83.5	90.3	86.5	4.1	4.3	4.9	4.1	3.3	3.0
58	S1-180		88.5	87.0	91.5	88.9	3.9	4.0	4.4	4.3	3.0	1.9
59	S1-182		86.6	84.0	89.6	86.6	3.8	5.0	4.0	3.5	3.0	2.6
60	S1-198		88.8	86.4	92.5	89.6	4.6	4.4	4.8	3.8	3.8	3.3
		MEAN:	87.8	85.2	90.4	87.5	4.4	4.1	4.8	4.1	2.5	2.3

TABLE A4 (CONTINUED)

SET# 4

EN	ENNAME	NT PS2 DAYS	FP PS2 DAYS	NT SK2 DAYS	FP SK2 DAYS	NT PI DAYS	FP PI DAYS	NT SKI DAYS	FP SKI DAYS	NT PSKI DAYS	FP PSKI DAYS
61	S1-3	85.4	83.6	87.5	86.1	3.6	4.5	4.8	4.1	2.1	2.5
62	S1-6	85.9	82.9	89.1	86.5	3.5	4.0	3.9	3.8	3.3	3.6
63	S1-7	86.1	83.8	89.0	86.4	5.1	5.6	5.6	4.8	2.9	2.6
64	S1-11	85.6	82.1	87.1	84.4	3.6	4.6	4.6	5.4	1.5	2.3
65	S1-14	86.8	84.4	90.1	87.0	4.0	3.5	6.3	3.6	3.4	2.6
66	S1-16	89.0	83.0	91.8	86.0	3.3	4.3	4.9	3.9	2.8	3.0
67	S1-20	88.5	84.3	90.6	87.4	5.0	3.6	4.5	3.9	2.1	3.1
68	S1-22	86.3	84.6	89.9	86.5	4.5	4.5	5.4	4.0	3.6	1.9
69	S1-24	86.8	84.4	88.0	85.9	5.6	4.5	4.3	4.4	1.3	1.5
70	S1-26	85.8	84.1	87.6	86.5	4.3	4.4	4.0	6.0	1.9	2.4
71	S1-28	86.8	83.6	87.9	85.4	4.3	3.6	4.1	3.4	1.1	1.8
72	S1-31	86.5	83.5	87.9	85.9	4.6	4.4	4.4	3.9	1.4	2.4
73	S1-33	85.5	84.3	88.0	87.3	5.5	3.6	5.6	3.8	2.5	3.0
74	S1-38	86.6	83.8	88.6	86.0	4.8	3.5	5.0	4.3	2.0	2.3
75	S1-55	84.8	82.0	87.6	85.1	4.6	4.0	4.4	4.0	2.9	3.1
76	S1-201	86.1	83.4	88.0	84.9	4.8	4.3	4.4	3.8	1.9	1.5
77	S1-68	85.6	81.8	88.5	85.6	4.3	4.6	5.1	5.5	2.9	3.9
78	S1-71	86.8	83.8	89.6	87.1	5.5	4.0	4.5	4.4	2.9	3.4
79	S1-82	87.0	84.5	90.4	88.5	4.4	4.0	4.5	4.3	3.4	4.0
80	S1-83	86.8	84.4	88.9	87.5	4.9	4.1	5.4	4.0	2.1	3.1
	MEAN:	86.4	83.6	88.8	86.3	4.5	4.2	4.8	4.2	2.4	2.7

TABLE A4 (CONTINUED)

SET# 5

EN	ENNAME		NT PS2	FP PS2	NT SK2	FP SK2	NT PI	FP PI	NT SKI	FP SKI	NT PSKI	FP PSKI
			DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS
81	S1-87		84.9	82.0	86.4	84.5	3.6	3.5	4.0	4.8	1.5	2.5
82	S1-90		87.0	85.0	90.5	87.3	5.3	3.9	4.8	3.1	3.5	2.3
83	S1-99		88.5	85.8	89.5	87.6	4.5	4.0	4.8	4.9	1.0	1.9
84	S1-103		84.9	83.5	87.6	86.3	4.8	4.3	3.8	4.3	2.8	2.8
85	S1-127		88.4	86.5	91.4	88.4	4.3	4.0	4.8	5.0	3.0	1.9
86	S1-130		86.5	85.3	89.3	87.4	3.9	4.4	4.0	4.6	2.8	2.1
87	S1-141		87.1	84.3	89.8	88.3	4.9	4.1	5.5	6.3	2.6	4.0
88	S1-143		86.6	83.6	89.6	87.4	3.6	4.8	5.1	3.8	3.0	3.8
89	S1-146		85.8	84.3	88.5	88.0	4.1	5.0	3.8	4.3	2.8	3.8
90	S1-156		88.0	84.0	90.0	86.0	4.8	3.8	4.4	4.4	2.0	2.0
91	S1-153		86.4	84.3	88.3	86.0	3.5	3.9	3.4	4.3	1.9	1.8
92	S1-157		87.8	86.0	91.1	90.0	4.3	4.8	4.6	4.1	3.4	4.0
93	S1-158		87.3	85.3	88.3	86.3	4.9	4.3	5.0	3.6	1.0	1.0
94	S1-165		86.4	85.4	91.1	88.8	4.6	4.1	4.6	3.1	4.8	3.4
95	S1-172		85.5	81.7	88.3	85.3	5.2	4.5	4.8	5.2	2.8	3.7
96	S1-185		84.0	81.8	85.9	83.3	4.3	4.8	4.0	3.6	1.9	1.5
97	S1-189		86.0	83.5	88.6	86.5	4.4	5.0	5.4	4.5	2.6	3.0
98	S1-190		86.6	84.9	89.5	87.8	5.1	4.5	4.9	3.8	2.9	2.9
99	S1-196		85.5	83.9	89.4	87.4	3.5	4.8	5.0	4.1	3.9	3.5
100	S1-197		85.8	84.8	88.4	88.1	2.8	4.5	3.6	4.8	2.6	3.4
		MEAN:	86.4	84.3	89.1	87.0	4.3	4.3	4.5	4.3	2.6	2.7

TABLE A5. ENTRY-TILLAGE MEANS FOR EXPERIMENT 1, FOR PFI, SHI, PHTS, EHTS, AND EPHTS

SET# 1

EN	ENNAME	NT PFI	FP PFI	NT SHI	FP SHI	NT PHTS CM	FP PHTS CM	NT EHTS CM	FP EHTS CM	NT EPHTS CM	FP EPHTS CM
1	S1-1	-1.11	1.79	304	492	14.8	11.7	9.7	11.4	3.6	5.1
2	S1-2	-16.63	-5.18	349	501	14.7	13.6	10.4	10.0	3.3	4.4
3	S1-4	-1.27	3.38	323	542	12.8	13.2	10.4	12.1	3.3	5.2
4	S1-5	-1.42	-1.97	353	527	15.0	13.4	10.4	11.5	3.5	4.9
5	S1-10	-5.36	-4.97	293	456	14.6	14.9	9.1	10.2	3.4	4.7
6	S1-32	0.10	3.22	423	555	19.1	16.0	12.2	14.5	4.3	5.6
7	S1-34	-16.95	-5.77	337	484	20.0	18.7	13.7	12.7	3.8	5.3
8	S1-35	-1.75	2.37	374	563	12.8	13.8	10.1	11.4	4.2	4.3
9	S1-36	-8.41	0.99	311	546	14.6	15.3	12.9	12.0	3.8	4.8
10	S1-37	-7.27	-2.32	337	531	13.6	11.8	10.5	10.8	4.0	4.5
11	S1-39	-2.28	6.60	350	585	15.2	17.3	13.7	13.8	3.6	5.8
12	S1-42	-7.11	-4.10	311	512	15.1	16.4	10.5	13.7	4.2	4.8
13	S1-43	0.52	-0.70	379	537	16.2	13.1	11.4	11.1	4.0	5.0
14	S1-45	-3.22	-9.09	303	460	12.6	12.7	9.4	12.5	4.1	5.5
15	S1-46	0.51	3.72	332	494	15.6	16.8	11.0	12.8	3.9	4.9
16	S1-47	1.39	-0.38	402	507	15.2	16.7	10.7	13.9	3.7	5.0
17	S1-48	-8.38	0.82	314	498	16.0	16.8	13.5	13.2	3.8	4.4
18	S1-49	-1.24	5.22	400	526	15.7	15.3	11.7	11.7	4.0	4.5
19	S1-57	0.13	4.46	373	577	15.4	12.8	11.4	9.1	3.6	5.4
20	S1-58	-0.21	-2.09	383	545	17.9	15.9	13.1	14.8	4.3	5.4
	MEAN:	-4.00	-0.20	348	522	15.3	14.8	11.3	12.2	3.8	5.0

TABLE A5 (CONTINUED)

EN	ENNAME		NT PFI	FP PFI	NT SHI	FP SHI	NT PHTS	FP PHTS	NT EHTS	FP EHTS	NT EPHTS	FP EPHTS
		SET# 2					CM	CM	CM	CM	CM	CM
21	S1-59		-0.77	-0.61	406	564	13.4	18.1	11.1	14.1	4.9	5.2
22	S1-60		2.70	2.26	382	542	13.2	15.1	9.1	10.8	3.8	4.4
23	S1-199		11.95	6.59	512	615	13.5	16.0	8.7	12.7	5.0	5.3
24	S1-200		7.20	4.23	467	553	15.7	15.9	12.1	12.8	5.1	4.9
25	S1-204		-3.82	-0.10	346	478	18.8	16.8	12.9	13.5	3.7	4.4
26	S1-61		-6.85	-4.93	349	477	11.9	15.6	10.7	12.0	4.0	5.2
27	S1-62		-3.50	1.74	420	539	11.5	13.2	11.7	10.8	3.9	4.1
28	S1-64		3.65	1.47	409	566	15.7	14.8	11.6	12.3	4.4	4.4
29	S1-66		-2.65	1.87	405	526	14.8	18.2	11.3	11.4	4.2	4.7
30	S1-67		-2.00	2.49	413	562	16.3	13.1	13.4	12.3	3.8	4.8
31	S1-70		-0.51	0.75	345	475	17.2	15.3	14.6	13.4	4.3	4.5
32	S1-72		1.26	4.11	424	573	16.1	14.6	13.1	13.6	4.0	5.4
33	S1-73		-3.11	3.76	385	552	16.3	14.7	13.1	12.6	4.7	5.5
34	S1-79		2.71	1.96	384	494	20.1	17.6	11.7	11.4	4.2	3.8
35	S1-80		13.19	8.00	503	613	17.3	17.5	14.6	15.1	4.4	4.5
36	S1-84		9.65	11.00	424	539	14.2	13.4	9.1	10.5	4.1	5.5
37	S1-104		-9.75	-3.87	408	495	21.4	17.6	14.7	14.9	4.5	3.6
38	S1-107		0.57	0.47	363	503	13.2	16.3	10.8	12.7	3.9	4.8
39	S1-113		-8.03	-3.62	321	469	13.4	16.2	10.5	12.5	3.1	4.0
40	S1-115		0.75	2.30	347	498	10.6	12.3	10.2	11.3	3.9	4.4
		MEAN:	0.63	1.99	401	532	15.2	15.6	11.7	12.5	4.2	4.7

TABLE A5 (CONTINUED)

SET# 3

EN	ENNAME	NT PFI	FP PFI	NT SHI	FP SHI	NT PHTS	FP PHTS	NT EHTS	FP EHTS	NT EPHTS	FP EPHTS
--	------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
						CM	CM	CM	CM	CM	CM
41	S1-116	-13.86	-9.22	307	401	13.8	12.4	11.6	8.8	3.8	4.7
42	S1-122	5.92	8.83	447	603	17.0	14.2	12.8	12.8	3.5	4.6
43	S1-123	-5.20	-2.03	357	506	16.6	17.8	13.4	12.5	4.2	4.8
44	S1-132	1.61	7.87	472	623	13.3	14.9	11.1	11.4	3.9	4.2
45	S1-136	0.99	2.51	356	507	12.6	15.8	8.8	9.4	3.9	5.4
46	S1-139	2.06	4.04	357	528	14.8	15.8	11.1	11.7	3.8	5.0
47	S1-151	0.85	2.46	386	537	16.6	16.4	14.0	15.1	3.9	4.8
48	S1-154	4.85	3.28	298	474	15.9	13.5	11.5	9.8	3.5	4.1
49	S1-155	-5.62	-0.60	331	483	17.2	16.1	12.8	13.1	3.8	4.5
50	S1-156	5.06	5.70	412	570	13.0	16.5	11.0	13.3	3.4	5.4
51	S1-160	-8.77	2.56	365	558	18.7	14.2	13.8	14.1	4.2	5.3
52	S1-162	-4.72	4.90	381	591	13.9	14.9	11.1	11.6	3.7	5.1
53	S1-163	-3.37	6.94	393	543	14.0	14.7	12.0	11.2	3.6	5.1
54	S1-167	2.31	0.95	399	572	14.1	13.8	10.7	12.7	3.5	3.7
55	S1-168	-3.77	0.15	329	527	18.8	17.9	13.2	13.3	3.9	5.8
56	S1-169	-2.93	1.32	385	557	16.2	15.1	11.8	12.3	3.7	4.8
57	S1-176	-3.85	1.45	339	511	16.3	14.9	10.5	12.2	3.1	4.1
58	S1-180	-7.11	-0.44	433	523	14.1	15.5	13.9	12.5	4.0	4.8
59	S1-182	5.04	9.08	398	626	15.5	16.6	11.4	10.4	3.4	3.8
60	S1-198	1.12	1.32	357	563	17.6	16.3	12.7	13.2	3.6	4.0
	MEAN:	-1.47	2.55	375	540	15.5	15.4	12.0	12.1	3.7	4.7

TABLE A5 (CONTINUED)

SET# 4

EN	ENNAME	NT PFI	FP PFI	NT SHI	FP SHI	NT PHTS	FP PHTS	NT EHTS	FP EHTS	NT EPHTS	FP EPHTS
						CM	CM	CM	CM	CM	CM
61	S1-3	8.08	0.83	394	500	17.3	17.3	13.5	11.6	3.6	4.2
62	S1-6	-1.66	-3.27	407	514	14.0	15.2	11.4	11.9	3.4	4.4
63	S1-7	-0.23	-1.19	326	478	16.5	14.1	10.6	11.4	3.2	4.8
64	S1-11	-2.58	-1.11	332	492	17.5	16.7	12.3	11.2	3.4	3.8
65	S1-14	-4.47	1.32	329	539	17.4	14.6	12.0	12.3	4.3	4.8
66	S1-16	-1.61	1.22	323	501	13.8	13.3	11.0	11.6	3.1	4.9
67	S1-20	-6.48	-0.47	365	518	16.9	13.5	10.9	10.4	3.0	3.9
68	S1-22	5.43	1.15	374	501	17.9	15.7	14.8	10.7	4.1	4.5
69	S1-24	-4.09	0.58	423	524	14.3	15.5	11.3	12.7	4.3	4.0
70	S1-26	-4.99	-5.59	301	426	18.6	14.7	12.5	11.4	4.1	6.0
71	S1-28	-3.74	-1.24	358	469	15.1	14.9	11.4	12.9	3.3	4.1
72	S1-31	2.45	3.27	389	511	14.4	12.4	11.9	11.0	3.0	4.7
73	S1-33	-24.91	-9.23	321	481	18.9	17.0	13.7	11.9	3.2	4.9
74	S1-38	1.33	4.89	402	505	15.6	14.9	12.1	12.6	4.7	4.0
75	S1-55	-7.79	-3.97	318	502	14.7	16.7	11.8	13.1	4.2	4.3
76	S1-201	1.17	2.71	421	569	12.7	12.7	10.1	11.4	3.6	4.7
77	S1-68	-6.16	-2.53	285	482	11.6	13.5	10.3	11.4	3.4	4.9
78	S1-71	-2.05	3.46	440	572	19.4	17.9	16.1	16.3	4.0	4.8
79	S1-82	10.58	2.45	445	507	19.6	15.9	13.6	13.5	3.8	4.8
80	S1-83	8.43	6.96	396	586	16.6	19.3	11.7	13.6	4.3	4.6
	MEAN:	-1.66	0.01	368	509	16.1	15.3	12.1	12.2	3.7	4.6

TABLE A5 (CONTINUED)

EN	ENNAME	SET# 5 NT PFI	FP PFI	NT SHI	FP SHI	NT PHTS CM	FP PHTS CM	NT EHTS CM	FP EHTS CM	NT EPHTS CM	FP EPHTS CM
81	S1-87	-8.92	2.21	370	562	14.7	15.9	11.5	13.3	3.5	5.7
82	S1-90	3.53	6.86	387	596	16.3	13.8	12.0	12.4	3.3	5.3
83	S1-99	-6.97	-2.80	372	540	17.2	15.1	13.2	10.8	4.5	5.1
84	S1-103	-3.28	2.28	368	550	13.6	12.7	11.9	10.7	4.1	5.9
85	S1-127	-8.26	-5.04	288	450	13.9	14.0	9.6	12.2	3.8	5.5
86	S1-130	-5.95	1.03	368	545	14.6	14.6	10.6	9.7	3.8	4.5
87	S1-141	1.12	-1.51	381	524	17.9	18.4	14.1	17.4	4.4	4.6
88	S1-143	0.59	8.17	423	622	16.8	17.2	12.4	12.4	4.2	5.5
89	S1-146	-1.35	-0.26	380	568	19.4	18.2	11.9	12.4	3.4	4.8
90	S1-156	6.57	3.62	356	491	14.7	13.9	10.6	11.0	4.4	4.9
91	S1-153	-1.37	4.81	376	544	14.5	18.2	11.8	15.5	3.4	4.5
92	S1-157	3.19	4.86	457	589	14.3	15.4	12.2	12.1	4.0	4.6
93	S1-158	-0.53	4.12	389	606	15.2	14.7	10.9	11.7	4.5	6.3
94	S1-165	-15.99	-2.06	348	535	16.4	17.2	11.0	12.5	3.5	5.1
95	S1-172	-2.28	-1.48	360	572	11.4	15.4	11.0	11.5	5.5	5.6
96	S1-185	-2.22	3.97	365	561	15.3	14.1	11.7	12.2	3.9	5.9
97	S1-189	1.99	4.55	435	595	18.7	16.6	13.7	13.4	4.6	4.2
98	S1-190	7.48	10.30	504	639	16.8	17.2	14.4	15.2	4.4	5.9
99	S1-196	-7.00	-2.80	371	560	17.5	14.2	12.5	13.8	3.6	4.4
100	S1-197	-5.31	1.55	308	500	14.7	14.5	10.6	13.2	4.0	4.5
	MEAN:	-2.25	2.12	380	557	15.7	15.6	11.9	12.7	4.0	5.1

TABLE A6. ENTRY-TILLAGE MEANS FOR EXPERIMENT 2, FOR GPMS, GPMSA, WPP, M, AND FST

SET# 1

EN	ENNAME		NT GPMS	FP GPMS	NT GPMSA	FP GPMSA	NT WPP	FP WPP	NT M	FP M	NT FST	FP FST
--	------		G/M2	G/M2	G/M2	G/M2	G	G	%	%	#/PLT	#/PLT
1	S1-3		295	458	296	454	65.9	91.9	25.7	25.5	39.4	43.8
2	S1-9		252	341	299	378	67.7	87.8	29.5	28.6	35.8	38.6
3	S1-41		381	448	399	467	86.9	97.9	23.8	22.7	38.7	41.8
4	S1-47		342	406	380	436	89.7	99.6	26.1	25.8	35.4	38.8
5	S1-49		336	466	361	462	84.0	89.7	24.9	24.6	37.7	44.3
6	S1-53		269	331	259	336	56.7	73.3	24.7	23.4	41.6	41.4
7	S1-88		359	442	368	421	78.2	83.0	26.2	24.0	39.7	45.2
8	S1-89		359	439	350	432	76.5	85.4	25.5	24.9	41.2	44.5
9	S1-90		330	494	297	462	63.1	88.8	27.7	27.0	44.5	46.8
10	S1-91		320	457	319	441	68.4	86.9	25.7	24.3	40.2	44.7
11	S1-94		403	513	364	489	76.2	94.2	25.8	24.7	44.2	46.0
12	S1-97		400	492	412	486	90.6	97.7	26.6	25.0	39.1	43.7
13	S1-128		340	456	338	436	77.5	88.1	27.8	26.2	37.5	43.9
14	S1-129		301	416	333	442	73.8	97.6	28.0	25.8	37.7	39.4
15	S1-131		374	538	348	526	73.4	102.8	28.3	27.2	43.4	44.9
16	S1-135		348	474	359	492	97.3	120.3	27.2	26.6	33.5	37.0
17	S1-136		403	419	391	400	82.8	78.9	28.0	26.6	41.9	44.4
18	S1-137		384	487	381	473	82.1	96.1	25.5	26.4	39.4	42.9
19	S1-148		361	477	340	456	71.5	89.7	27.9	27.7	42.8	44.3
20	S1-150		402	464	366	422	77.3	81.1	23.7	24.3	44.4	47.9
		MEAN:	348	451	348	446	77.0	91.5	26.4	25.6	39.9	43.2

TABLE A6 (CONTINUED)

SET# 2

EN	ENNAME	NT GPMS	FP GPMS	NT GPMSA	FP GPMSA	NT WPP	FP WPP	NT M	FP M	NT FST	FP FST
--	------	G/M2	G/M2	G/M2	G/M2	G	G	%	%	#/PLT	#/PLT
21	S1-151	313	368	333	370	76.2	76.6	25.1	22.6	37.9	42.7
22	S1-185	404	487	390	474	83.3	93.9	27.8	27.4	41.8	44.6
23	S1-192	312	454	297	471	64.1	99.7	30.8	28.5	42.2	42.1
24	S1-203	393	426	356	430	74.2	86.9	28.3	28.1	44.6	43.6
25	S1-204	385	430	385	430	85.1	87.3	27.5	26.4	40.8	43.2
26	S1-207	307	418	389	456	113.9	143.2	29.3	28.5	31.0	33.5
27	S1-208	375	410	400	426	89.0	98.1	28.1	26.8	36.4	39.4
28	S1-209	204	278	283	328	81.4	189.2	26.7	24.3	31.3	29.9
29	S1-213	295	368	304	387	64.2	85.3	30.1	28.4	39.3	40.3
30	S1-214	380	475	376	482	80.7	99.2	27.9	26.5	40.7	42.5
31	S1-219	364	478	346	457	76.1	89.9	25.9	24.2	41.1	45.3
32	S1-222	254	431	276	417	61.4	83.8	24.7	24.4	37.4	44.4
33	S1-224	367	401	336	401	72.1	81.0	23.6	23.6	44.0	43.5
34	S1-243	375	483	369	487	83.0	102.6	26.7	26.4	40.4	42.1
35	S1-251	380	518	346	512	74.0	105.1	27.5	26.2	43.7	43.3
36	S1-253	371	389	362	408	81.9	95.6	27.4	26.9	39.3	39.4
37	S1-258	364	477	348	481	72.5	96.3	28.6	27.2	42.4	43.3
38	S1-260	342	456	328	462	74.7	96.2	26.5	24.6	39.7	43.3
39	S1-265	382	482	336	457	71.4	89.0	27.1	26.3	45.6	46.0
40	S1-268	322	429	332	428	75.9	91.6	24.4	25.9	37.1	40.8
	MEAN:	345	433	345	438	77.7	99.5	27.2	26.2	39.8	41.7

TABLE A6 (CONTINUED)

SET# 3

EN	ENNAME		NT GPMS	FP GPMS	NT GPMSA	FP GPMSA	NT WPP	FP WPP	NT M	FP M	NT FST	FP FST
			G/M2	G/M2	G/M2	G/M2	G	G	%	%	#/PLT	#/PLT
41	S1-1		325	504	325	504	57.2	87.0	24.7	24.4	47.7	48.7
42	S1-2		349	511	349	511	63.3	94.5	29.2	28.7	46.5	45.3
43	S1-7		229	273	229	273	41.0	48.0	27.0	27.3	46.3	47.3
44	S1-11		345	429	345	429	61.5	77.7	25.4	25.6	47.2	46.2
45	S1-12		352	421	352	421	63.7	75.0	23.2	24.6	46.2	47.2
46	S1-14		248	396	248	396	45.9	71.2	30.6	29.8	45.5	46.5
47	S1-15		442	570	442	570	78.0	101.5	27.0	27.8	47.3	47.0
48	S1-17		346	439	346	439	60.8	75.2	25.5	26.8	47.8	48.8
49	S1-19		388	437	388	437	69.2	78.7	28.4	29.2	47.2	46.5
50	S1-22		257	424	257	424	46.5	76.5	23.7	23.2	46.2	46.3
51	S1-24		465	538	465	538	84.6	96.9	25.9	26.9	46.2	46.3
52	S1-25		323	477	323	477	59.2	86.7	25.4	25.7	45.7	46.5
53	S1-27		367	488	367	488	66.6	91.2	25.2	25.6	46.3	44.7
54	S1-29		474	501	474	501	87.5	93.1	26.9	27.1	45.7	45.0
55	S1-30		298	400	298	400	54.4	70.0	29.5	29.0	45.8	47.8
56	S1-32		406	468	406	468	74.0	82.9	27.4	29.2	46.2	47.2
57	S1-34		301	420	301	420	53.7	77.1	23.6	23.3	46.5	45.8
58	S1-35		418	516	418	516	73.7	94.0	25.4	27.3	47.2	46.0
59	S1-37		404	590	404	590	72.0	104.6	27.7	27.8	47.2	47.2
60	S1-40		311	413	311	413	58.0	75.7	26.3	26.7	44.8	45.7
		MEAN:	352	461	352	461	63.5	82.9	26.4	26.8	46.5	46.6

TABLE A6 (CONTINUED)

SET# 4

EN	ENNAME	NT GPMS	FP GPMS	NT GPMSA	FP GPMSA	NT WPP	FP WPP	NT M	FP M	NT FST	FP FST
		G/M2	G/M2	G/M2	G/M2	G	G	%	%	#/PLT	#/PLT
61	S1-44	316	414	316	414	56.5	75.6	25.3	26.5	47.0	45.8
62	S1-45	379	427	379	427	67.6	80.1	24.6	25.8	47.0	45.0
63	S1-46	340	429	340	429	62.4	80.8	22.9	23.4	45.5	44.5
64	S1-54	400	487	400	487	72.6	86.3	26.8	26.3	46.0	47.2
65	S1-56	310	316	310	316	55.7	56.7	25.3	26.7	46.5	46.7
66	S1-57	264	387	264	387	47.0	68.8	25.5	25.8	47.0	47.5
67	S1-59	376	456	376	456	67.2	80.0	24.0	25.6	46.7	47.8
68	S1-61	422	498	422	498	73.5	90.3	29.5	31.4	48.2	46.5
69	S1-64	369	469	369	469	66.9	86.7	22.6	23.3	46.2	45.3
70	S1-65	370	452	370	452	68.1	83.0	23.5	24.2	45.2	45.5
71	S1-69	372	422	372	422	66.2	74.5	26.7	27.8	47.0	47.5
72	S1-70	314	462	314	462	55.0	85.6	28.6	27.4	47.5	45.2
73	S1-72	333	337	333	337	58.0	59.8	24.2	25.5	48.2	47.2
74	S1-152	375	440	375	440	68.8	86.1	27.3	27.3	45.3	43.2
75	S1-153	338	379	338	379	59.1	70.1	28.7	30.0	48.3	45.3
76	S1-76	300	366	300	366	56.5	70.6	25.2	26.2	44.5	43.8
77	S1-77	436	475	436	475	78.4	83.9	27.1	27.1	46.5	47.2
78	S1-78	353	435	353	435	64.8	78.4	24.9	25.7	45.7	46.7
79	S1-81	329	463	329	463	60.3	82.1	26.6	26.7	46.0	47.2
80	S1-82	409	524	409	524	74.7	92.6	26.9	28.2	46.2	47.3
	MEAN:	355	432	355	432	64.0	78.6	25.8	26.6	46.5	46.1

TABLE A6 (CONTINUED)

SET# 5

EN	ENNAME	NT GPMS	FP GPMS	NT GPMSA	FP GPMSA	NT WPP	FP WPP	NT M	FP M	NT FST	FP FST
		G/M2	G/M2	G/M2	G/M2	G	G	%	%	#/PLT	#/PLT
81	S1-83	340	475	340	475	65.0	84.5	25.2	25.9	44.7	47.2
82	S1-86	332	398	332	398	60.9	72.2	27.3	27.7	45.7	46.0
83	S1-155	337	414	337	414	63.0	73.8	28.2	27.9	45.8	47.2
84	S1-95	294	495	294	495	56.3	87.3	26.9	27.8	44.7	47.7
85	S1-177	439	474	439	474	78.9	84.6	24.4	25.1	46.7	47.0
86	S1-182	334	432	334	432	60.0	74.7	24.1	26.3	46.8	48.5
87	S1-226	388	423	388	423	68.7	74.0	23.9	24.5	47.5	47.8
88	S1-234	307	391	307	391	58.7	71.4	24.9	25.1	44.0	45.7
89	S1-237	373	486	373	486	74.6	90.3	27.5	28.5	41.8	45.2
90	S1-241	257	397	257	397	54.3	73.9	24.9	24.4	42.8	44.7
91	S1-248	404	444	404	444	72.6	81.3	22.8	24.1	46.7	45.8
92	S1-101	406	448	406	448	73.1	82.8	24.0	24.1	46.8	45.2
93	S1-156	346	482	346	482	64.4	84.5	26.4	26.4	46.0	47.8
94	S1-113	265	356	265	356	48.6	63.5	32.5	30.0	46.0	46.8
95	S1-121	320	456	320	456	58.7	82.2	30.3	29.9	45.8	46.5
96	S1-122	400	462	400	462	76.8	82.6	25.4	26.8	44.2	46.8
97	S1-123	413	416	413	416	74.4	77.1	28.2	29.0	46.8	45.2
98	S1-124	429	585	429	585	79.9	105.4	26.7	26.4	45.3	46.5
99	S1-126	379	419	379	419	70.5	72.9	28.3	29.4	45.3	48.2
100	S1-149	259	424	259	424	47.2	71.7	24.7	27.9	46.7	49.5
	MEAN:	351	444	351	444	65.3	79.5	26.3	26.9	45.5	46.8

TABLE A7. ENTRY-TILLAGE MEANS FOR EXPERIMENT 2, FOR PSL, PRL, PDE, PHT, EHT, AND SG

SET# 1

EN	ENNAME	NT PSL	FP PSL	NT PRL	FP PRL	NT PDE	FP PDE	NT PHT	FP PHT	NT EHT	FP EHT	NT SG	FP SG
		%	%	%	%	%	%	CM	CM	CM	CM	1-9	1-9
1	S1-3	19.3	26.4	0.7	1.1	0.0	0.2	165	177	87	82	4.5	4.8
2	S1-9	11.3	14.2	0.5	0.8	0.0	0.0	176	186	82	89	4.9	3.9
3	S1-41	11.3	16.2	1.3	1.9	0.0	0.0	173	189	105	100	4.2	4.7
4	S1-47	15.7	17.9	0.2	0.7	0.2	0.4	157	167	74	80	4.0	4.3
5	S1-49	16.2	20.7	1.7	4.9	0.2	0.6	186	189	89	92	5.0	4.2
6	S1-53	20.2	27.6	1.1	3.0	0.2	0.0	199	201	112	102	2.7	2.1
7	S1-88	14.9	22.7	0.2	1.7	0.0	0.2	176	182	94	90	4.0	3.4
8	S1-89	14.5	14.2	0.8	1.3	0.0	0.0	195	198	97	93	3.1	2.5
9	S1-90	19.1	25.3	0.0	0.0	0.0	0.2	173	182	80	82	2.8	2.5
10	S1-91	17.0	20.9	0.5	0.4	0.0	0.2	180	194	84	95	4.2	4.6
11	S1-94	16.6	23.9	0.4	4.1	0.5	0.2	177	189	87	91	3.8	3.5
12	S1-97	7.4	12.8	2.3	9.3	0.0	0.2	189	196	96	100	5.6	5.7
13	S1-128	16.6	26.6	3.3	6.6	0.0	0.0	180	194	90	104	5.5	5.4
14	S1-129	32.4	22.1	0.8	3.8	0.0	0.0	196	202	96	103	5.2	4.7
15	S1-131	10.9	20.1	0.2	1.5	0.0	0.0	175	181	92	91	4.7	5.4
16	S1-135	11.1	13.7	3.3	4.5	0.2	0.0	187	191	90	87	4.3	4.6
17	S1-136	12.7	17.2	1.1	2.5	0.0	0.2	193	202	90	93	4.2	3.8
18	S1-137	14.3	21.2	0.5	1.8	0.5	0.3	175	199	87	90	4.1	3.9
19	S1-148	9.7	14.8	1.6	5.7	0.2	0.0	183	196	94	95	5.6	5.5
20	S1-150	21.0	24.8	0.3	0.6	0.0	0.2	171	178	69	86	4.2	3.5
	MEAN:	15.6	20.2	1.0	2.8	0.1	0.2	180	190	90	92	4.3	4.1

TABLE A7 (CONTINUED)

		SET# 2											
EN	ENNAME	NT PSL	FP PSL	NT PRL	FP PRL	NT PDE	FP PDE	NT PHT	FP PHT	NT EHT	FP EHT	NT SG	FP SG
		%	%	%	%	%	%	CM	CM	CM	CM	1-9	1-9
21	S1-151	8.9	29.4	0.9	1.8	0.0	0.2	162	171	78	86	2.4	1.6
22	S1-185	13.4	15.5	0.5	0.8	0.0	0.2	176	187	76	87	4.4	5.6
23	S1-192	5.9	10.7	0.8	5.2	0.0	0.0	165	170	80	85	5.4	4.8
24	S1-203	12.1	24.2	0.0	1.1	0.0	0.2	161	162	72	78	4.9	4.7
25	S1-204	14.6	28.0	2.6	1.7	0.0	0.0	190	198	91	101	4.7	4.4
26	S1-207	22.1	25.8	2.3	2.5	0.0	0.0	189	201	92	103	4.3	3.7
27	S1-208	6.2	7.4	10.0	11.8	0.2	0.0	181	188	90	95	4.6	4.0
28	S1-209	14.5	16.7	0.9	3.0	0.0	0.0	168	184	73	83	4.7	4.3
29	S1-213	17.1	19.2	0.9	2.8	0.0	0.0	183	195	81	87	4.8	4.2
30	S1-214	27.1	22.8	1.7	5.0	0.0	0.0	197	201	97	107	5.0	5.4
31	S1-219	4.8	6.8	1.3	5.5	0.3	0.0	184	188	81	86	4.7	4.6
32	S1-222	14.3	15.8	0.2	0.8	0.0	0.2	168	175	63	73	2.5	2.2
33	S1-224	11.5	20.3	0.0	5.3	0.2	0.2	163	167	70	78	4.1	3.8
34	S1-243	12.5	14.0	0.0	0.7	0.2	0.2	188	202	92	104	3.7	4.0
35	S1-251	10.0	14.6	2.7	5.8	0.0	0.0	187	203	87	100	5.4	6.1
36	S1-253	8.3	12.8	0.0	5.2	0.0	0.0	175	180	79	87	4.2	4.4
37	S1-258	13.0	11.4	4.8	12.6	0.2	0.0	177	187	84	91	5.1	4.6
38	S1-260	14.9	12.7	1.0	5.6	0.0	0.0	189	194	82	89	3.8	3.9
39	S1-265	32.4	32.8	1.5	2.7	0.7	0.0	193	198	93	95	2.2	1.4
40	S1-268	9.6	9.5	0.0	6.2	0.0	0.3	174	188	69	84	4.1	4.3
	MEAN:	13.7	17.5	1.6	4.3	0.1	0.1	178	187	82	90	4.3	4.1

TABLE A7 (CONTINUED)

SET# 3

EN	ENNAME	NT PSL	FP PSL	NT PRL	FP PRL	NT PDE	FP PDE	NT PHT	FP PHT	NT EHT	FP EHT	NT SG	FP SG
--	------	%	%	%	%	%	%	CM	CM	CM	CM	1-9	1-9
41	S1-1	11.9	14.4	0.0	6.2	0.3	0.0	182	195	85	94	2.3	3.2
42	S1-2	21.3	17.1	0.0	8.5	0.3	0.3	196	205	93	100	3.7	4.3
43	S1-7	36.0	41.5	1.1	7.6	0.0	0.0	197	216	91	102	4.8	4.5
44	S1-11	21.2	13.1	1.1	11.6	0.7	0.0	207	224	109	119	4.0	4.7
45	S1-12	20.0	22.6	2.8	6.5	0.0	0.0	181	193	79	86	3.8	4.5
46	S1-14	28.2	18.1	4.1	22.3	0.4	0.0	209	232	115	130	5.2	6.5
47	S1-15	21.5	28.7	0.3	2.7	0.4	0.0	196	205	97	102	3.7	4.5
48	S1-17	30.9	32.2	1.0	8.4	1.7	0.0	187	199	99	107	3.0	4.3
49	S1-19	20.4	19.9	3.0	9.3	0.0	0.3	197	206	92	101	6.7	6.7
50	S1-22	18.5	19.9	1.8	4.3	0.0	0.0	175	190	74	87	3.5	4.2
51	S1-24	25.1	32.5	0.7	1.5	0.3	0.4	192	203	87	95	4.2	4.7
52	S1-25	34.4	35.7	0.0	0.7	0.0	0.0	175	188	81	86	4.5	5.0
53	S1-27	21.8	31.9	0.0	1.5	0.0	0.4	177	196	86	100	4.5	4.7
54	S1-29	6.3	21.5	0.0	7.6	0.0	0.0	190	206	77	87	3.7	4.3
55	S1-30	26.2	28.5	1.1	11.2	0.0	0.0	191	210	95	110	3.7	2.8
56	S1-32	17.9	14.8	2.3	12.6	0.0	0.0	191	198	87	92	4.8	6.0
57	S1-34	39.2	36.2	0.0	1.5	0.0	0.0	183	194	77	91	2.5	3.2
58	S1-35	13.6	14.7	2.9	6.9	0.0	0.3	178	190	76	86	4.2	5.3
59	S1-37	23.0	24.9	1.4	7.0	0.0	0.0	199	215	92	102	4.0	5.2
60	S1-40	19.7	24.9	4.5	12.7	0.0	0.4	190	206	88	98	4.2	4.7
	MEAN:	22.9	24.7	1.4	7.5	0.2	0.1	190	203	89	99	4.0	4.7

TABLE A7 (CONTINUED)

EN	ENNAME	NT PSL	FP PSL	NT PRL	FP PRL	NT PDE	FP PDE	NT PHT	FP PHT	NT EHT	FP EHT	NT SG	FP SG
		SET# 4											
--	------	%	%	%	%	%	%	CM	CM	CM	CM	1-9	1-9
61	S1-44	42.2	47.9	1.9	7.6	0.0	0.0	192	205	98	104	4.7	5.0
62	S1-45	16.0	35.0	3.8	3.5	0.4	0.3	188	199	77	82	5.2	5.3
63	S1-46	23.9	26.6	0.4	6.5	0.0	0.0	187	207	84	117	4.3	4.8
64	S1-54	30.7	27.0	2.2	21.2	0.0	0.0	205	218	101	109	4.8	5.5
65	S1-56	50.1	54.5	0.7	17.7	0.4	0.0	207	222	97	108	3.0	4.2
66	S1-57	33.2	34.7	1.1	6.6	0.0	0.0	188	196	84	94	2.3	3.2
67	S1-59	33.3	39.0	0.0	0.4	0.0	0.0	190	199	83	88	1.2	1.5
68	S1-61	7.0	10.1	10.0	23.9	0.0	0.0	185	198	91	105	6.0	6.7
69	S1-64	12.7	12.5	1.9	13.8	0.0	0.4	187	194	79	85	4.2	4.7
70	S1-65	20.9	28.1	3.0	6.1	0.0	0.7	196	198	79	86	4.2	4.2
71	S1-69	35.7	39.9	6.3	29.5	0.0	0.0	207	213	115	115	7.0	6.7
72	S1-70	11.3	17.0	1.7	11.0	0.3	0.0	187	200	83	94	4.8	5.5
73	S1-72	24.8	31.7	0.4	2.4	0.0	0.7	194	208	88	98	1.3	1.5
74	S1-152	27.9	33.0	1.5	6.0	0.0	0.0	185	196	87	89	3.3	4.7
75	S1-153	50.6	53.4	6.0	18.6	0.0	0.0	177	191	76	83	4.8	5.2
76	S1-76	22.9	26.5	0.0	7.7	0.0	0.0	187	196	82	89	3.0	3.5
77	S1-77	9.9	11.7	1.4	7.1	0.4	0.0	194	210	87	100	3.7	4.7
78	S1-78	26.7	26.1	0.0	5.0	0.3	0.0	182	190	76	85	2.2	3.5
79	S1-81	17.4	29.9	1.9	7.0	0.0	0.0	188	195	82	90	5.0	4.7
80	S1-82	13.3	21.8	3.8	12.3	0.0	0.0	184	194	85	95	6.2	6.7
	MEAN:	25.5	30.3	2.4	10.7	0.1	0.1	190	201	87	96	4.1	4.6

TABLE A7 (CONTINUED)

EN	ENNAME		SET# 5 NT PSL	FP PSL	NT PRL	FP PRL	NT PDE	FP PDE	NT PHT	FP PHT	NT EHT	FP EHT	NT SG	FP SG
--	------		%	%	%	%	%	%	CM	CM	CM	CM	1-9	1-9
81	S1-83		25.6	29.2	2.7	4.6	0.4	0.0	192	213	94	103	3.3	2.5
82	S1-86		49.8	47.7	0.7	8.6	0.0	0.0	206	222	106	114	3.5	2.8
83	S1-155		12.6	22.2	2.1	8.3	0.0	0.0	174	194	79	90	5.5	6.0
84	S1-95		19.3	23.5	0.7	9.4	0.0	0.0	175	198	77	92	3.8	5.5
85	S1-177		31.9	48.1	0.0	0.7	0.0	0.0	194	218	91	106	3.5	3.7
86	S1-182		23.7	33.9	1.8	5.2	0.4	0.0	177	191	81	90	3.5	4.7
87	S1-226		28.6	26.3	0.0	2.8	0.0	0.0	186	200	87	94	3.7	4.2
88	S1-234		26.4	38.3	0.8	4.5	0.3	0.0	186	203	80	92	1.7	1.8
89	S1-237		11.8	14.4	6.5	23.2	0.8	0.4	188	204	85	98	4.8	5.5
90	S1-241		21.6	37.1	0.7	4.1	0.0	0.0	178	194	82	93	1.5	1.5
91	S1-248		10.8	30.0	0.3	7.2	0.0	0.0	182	197	77	89	1.5	2.5
92	S1-101		23.4	37.8	0.0	2.4	0.0	0.0	194	213	81	92	2.0	2.0
93	S1-156		35.9	36.1	1.1	4.7	0.0	0.0	186	206	88	106	3.7	4.0
94	S1-113		12.4	36.4	3.4	11.4	0.3	0.4	183	202	88	98	4.0	3.8
95	S1-121		29.7	43.0	15.3	13.9	0.0	0.0	210	229	117	127	5.0	5.8
96	S1-122		16.7	30.9	7.0	18.8	0.8	0.0	188	203	93	101	5.2	5.8
97	S1-123		13.5	20.0	2.0	7.2	0.3	0.0	188	204	83	89	3.8	3.5
98	S1-124		14.9	13.6	0.0	2.1	0.0	0.0	187	204	77	90	4.2	4.2
99	S1-126		23.5	32.1	7.7	19.9	0.0	0.0	172	197	87	106	5.5	5.8
100	S1-149		32.3	27.1	0.7	3.5	0.4	0.0	188	214	91	108	2.2	2.8
		MEAN:	23.2	31.4	2.7	8.1	0.2	0.0	187	205	87	99	3.6	3.9

TABLE A8. ENTRY-TILLAGE MEANS FOR EXPERIMENT 2, FOR PEM, EV, EMI, EPHT, AND BMPP

SET# 1

EN	ENNAME		NT PEM	FP PEM	NT EV	FP EV	NT EMI	FP EMI	NT EPHT	FP EPHT	NT BMPP	FP BMPP
			%	%	1-9	1-9	DAYS	DAYS	CM	CM	CM	CM
1	S1-3		54.8	65.7	4.1	5.3	22.8	17.9	17.2	24.8	93	166
2	S1-9		68.5	73.5	3.6	4.3	23.8	16.4	13.5	25.9	93	167
3	S1-41		72.3	74.5	4.3	4.8	22.7	17.5	18.3	24.7	129	176
4	S1-47		69.2	68.4	4.8	4.3	23.8	16.2	16.6	20.9	116	131
5	S1-49		67.9	80.7	4.2	5.3	22.0	16.5	18.4	25.8	121	202
6	S1-53		70.5	79.4	4.5	5.7	16.2	17.4	18.7	24.0	130	184
7	S1-88		70.8	82.1	4.1	5.6	20.5	17.6	16.9	27.5	122	216
8	S1-89		76.9	82.5	4.7	5.7	22.9	17.5	19.4	25.9	151	204
9	S1-90		78.4	85.7	4.4	5.5	22.1	16.6	17.1	24.8	131	205
10	S1-91		74.5	83.5	3.9	5.0	21.5	17.5	16.2	23.2	116	186
11	S1-94		80.0	83.9	4.9	5.5	22.4	19.1	16.9	25.7	134	211
12	S1-97		71.4	76.9	4.0	5.1	22.0	17.9	17.5	25.5	119	185
13	S1-128		58.0	72.8	4.2	5.4	22.6	18.5	17.9	25.1	102	176
14	S1-129		65.6	73.2	4.0	4.9	22.4	16.4	15.3	24.1	101	167
15	S1-131		74.2	80.1	4.3	5.0	23.2	19.4	16.4	21.6	121	170
16	S1-135		54.3	57.9	3.5	4.4	21.6	17.5	17.0	26.0	90	152
17	S1-136		75.8	79.0	4.8	6.3	23.4	16.7	19.1	28.1	142	207
18	S1-137		73.1	76.9	5.0	5.9	23.0	18.2	19.3	26.4	143	197
19	S1-148		79.8	83.1	5.1	5.6	23.9	17.3	18.4	27.6	144	223
20	S1-150		82.3	89.0	5.1	5.8	22.0	17.5	19.0	25.6	153	224
		MEAN:	70.9	77.4	4.4	5.3	22.2	17.5	17.5	25.2	123	187

TABLE A8 (CONTINUED)

SET# 2

EN	ENNAME		NT PEM	FP PEM	NT EV	FP EV	NT EMI	FP EMI	NT EPHT	FP EPHT	NT BMPP	FP BMPP
--	------		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
			%	%	1-9	1-9	DAYS	DAYS	CM	CM	CM	CM
21	S1-151		67.6	76.4	4.1	5.2	20.5	17.4	17.0	24.1	111	177
22	S1-185		71.6	77.4	4.6	5.4	22.6	18.0	18.1	21.1	128	160
23	S1-192		73.5	75.7	4.3	5.3	21.5	17.4	15.9	24.1	113	169
24	S1-203		78.9	82.3	4.7	5.5	21.8	19.4	17.0	22.5	132	182
25	S1-204		72.5	82.4	4.1	6.0	22.7	16.9	18.1	27.5	128	217
26	S1-207		59.2	60.4	4.1	4.0	23.8	14.7	17.8	22.9	95	123
27	S1-208		69.0	71.2	4.5	4.6	23.0	17.9	18.6	24.9	129	171
28	S1-209		58.3	56.4	3.7	3.9	21.6	4.8	15.5	20.3	85	103
29	S1-213		67.3	74.7	4.3	5.1	23.7	17.7	15.9	21.1	106	150
30	S1-214		74.5	76.3	4.9	5.3	22.2	19.3	19.7	25.3	143	185
31	S1-219		77.0	84.2	5.0	6.1	21.3	17.0	19.9	26.4	148	218
32	S1-222		70.0	82.3	4.7	5.8	23.1	18.4	18.9	26.8	135	214
33	S1-224		81.0	83.2	5.3	6.0	21.8	17.7	18.3	23.5	147	194
34	S1-243		74.4	71.2	4.6	4.9	22.1	19.5	18.4	24.3	130	168
35	S1-251		77.1	74.6	4.6	5.6	21.6	16.8	19.0	26.6	141	192
36	S1-253		71.5	70.1	5.0	4.6	19.7	18.4	19.4	24.9	136	161
37	S1-258		77.9	77.2	4.9	5.7	21.3	15.3	17.8	25.5	135	191
38	S1-260		72.7	78.5	4.2	5.6	22.3	18.1	18.0	24.8	130	187
39	S1-265		85.3	86.3	4.9	5.9	21.5	16.8	18.5	25.8	155	216
40	S1-268		64.4	75.5	4.3	5.6	20.1	17.4	20.7	29.0	129	217
		MEAN:	72.2	75.8	4.5	5.3	21.9	17.0	18.1	24.6	128	180

TABLE A8 (CONTINUED)

SET# 3

EN	ENNAME	NT PEM	FP PEM	NT EV	FP EV	NT EMI	FP EMI	NT EPHT	FP EPHT	NT BMPP	FP BMPP
		%	%	1-9	1-9	DAYS	DAYS	CM	CM	CM	CM
41	S1-1	92.8	95.2	5.7	6.5	18.7	18.1	15.5	21.1	143	200
42	S1-2	94.2	91.C	5.8	6.7	18.4	17.9	16.8	21.6	158	198
43	S1-7	94.3	94.3	5.7	6.3	18.7	17.7	15.5	15.9	146	151
44	S1-11	89.5	93.0	5.5	6.3	18.5	18.2	17.7	20.2	160	187
45	S1-12	91.2	93.8	6.7	6.5	18.4	18.2	17.9	19.7	162	186
46	S1-14	93.8	93.5	5.7	5.8	18.0	18.2	14.3	18.0	135	169
47	S1-15	93.7	90.8	6.2	7.2	18.4	17.9	18.5	21.1	174	194
48	S1-17	95.7	94.0	6.2	5.8	18.5	17.7	17.0	17.5	163	166
49	S1-19	92.3	89.5	5.5	6.0	19.0	19.0	16.9	19.5	156	176
50	S1-22	98.0	96.5	6.3	7.0	18.4	18.5	15.9	19.4	156	187
51	S1-24	92.7	97.7	6.8	7.8	18.9	17.9	17.2	23.2	160	227
52	S1-25	94.7	94.2	6.0	7.0	19.4	18.6	16.1	22.0	153	208
53	S1-27	94.7	91.5	6.0	6.3	18.8	17.7	18.4	22.0	174	205
54	S1-29	93.2	94.3	6.3	6.3	18.0	18.5	18.2	21.0	171	199
55	S1-30	94.5	94.8	6.7	7.2	18.6	18.1	17.7	22.0	168	210
56	S1-32	93.5	91.7	6.5	6.5	17.7	17.8	18.8	20.1	175	186
57	S1-34	97.0	95.7	6.2	7.2	18.9	18.3	17.2	20.2	167	193
58	S1-35	93.2	91.3	7.3	7.3	18.5	18.1	18.4	22.7	172	209
59	S1-37	93.7	92.3	6.5	6.3	17.8	18.0	15.9	18.5	149	171
60	S1-40	93.0	91.5	5.8	6.0	18.7	18.1	16.7	18.2	156	168
	MEAN:	93.8	93.3	6.2	6.6	18.5	18.1	17.0	20.2	160	189

TABLE A8 (CONTINUED)

SET# 4

EN	ENNAME	NT PEM	FP PEM	NT EV	FP EV	NT EMI	FP EMI	NT EPHT	FP EPHT	NT BMPP	FP BMPP
--	------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
		%	%	1-9	1-9	DAYS	DAYS	CM	CM	CM	CM
61	S1-44	94.7	91.8	6.2	6.2	18.8	17.9	15.1	18.2	143	167
62	S1-45	93.0	90.0	5.3	5.8	18.5	18.0	16.2	19.7	150	181
63	S1-46	84.7	90.3	4.7	5.5	18.3	18.1	15.8	17.5	133	160
64	S1-54	91.3	90.8	5.8	6.3	19.4	18.3	15.3	19.5	140	177
65	S1-56	91.7	91.0	6.8	5.7	18.3	18.1	17.9	18.2	163	166
66	S1-57	92.3	91.2	6.0	6.2	18.4	18.1	16.7	17.8	154	164
67	S1-59	95.7	92.7	7.5	6.8	17.9	17.7	20.5	21.4	196	199
68	S1-61	88.8	85.0	5.5	5.3	18.1	18.3	15.0	17.7	133	153
69	S1-64	89.0	85.5	5.8	6.5	18.5	18.5	17.6	19.6	156	169
70	S1-65	88.5	83.3	5.8	6.2	18.7	18.3	16.6	18.8	146	160
71	S1-69	93.0	91.3	5.5	6.2	18.9	18.3	16.1	17.9	148	164
72	S1-70	95.3	91.8	5.5	6.3	18.3	18.0	16.7	19.0	160	176
73	S1-72	93.5	88.0	6.5	5.7	18.3	18.0	19.4	19.2	180	170
74	S1-152	90.5	81.7	6.7	5.3	18.6	17.6	17.6	18.4	160	152
75	S1-153	95.0	86.0	6.0	5.5	18.3	18.4	15.9	16.2	150	139
76	S1-76	82.5	84.5	5.3	5.3	19.6	18.9	15.1	17.0	127	146
77	S1-77	89.3	90.5	5.8	5.8	18.6	17.8	17.5	20.4	156	185
78	S1-78	92.5	92.7	5.3	5.0	19.0	18.4	16.8	15.6	156	145
79	S1-81	93.0	94.5	5.3	6.0	18.9	18.8	15.6	18.3	144	174
80	S1-82	91.3	87.7	6.2	6.5	19.1	17.9	17.3	20.8	158	186
	MEAN:	91.3	89.0	5.9	5.9	18.6	18.2	16.7	18.6	153	167

TABLE A8 (CONTINUED)

SET# 5

EN	ENNAME		NT PEM	FP PEM	NT EV	FP EV	NT EMI	FP EMI	NT EPHT	FP EPHT	NT BMPP	FP BMPP
			%	%	1-9	1-9	DAYS	DAYS	CM	CM	CM	CM
81	S1-83		89.5	93.2	5.7	6.7	20.6	17.9	15.6	19.7	139	184
82	S1-86		89.8	94.7	5.5	5.5	18.2	18.4	17.2	18.3	155	173
83	S1-155		92.3	93.5	5.2	5.5	18.4	18.0	15.4	20.0	143	187
84	S1-95		94.2	95.2	5.0	6.3	18.9	18.6	13.1	18.6	123	177
85	S1-177		91.2	96.0	6.5	6.8	18.8	17.9	18.2	22.2	165	213
86	S1-182		91.8	90.7	7.0	6.2	18.9	18.2	18.3	19.0	168	172
87	S1-226		91.7	94.0	6.5	6.8	18.4	18.0	18.1	20.7	166	195
88	S1-234		90.0	93.2	6.7	7.2	18.3	18.2	17.6	22.3	159	209
89	S1-237		93.0	93.5	6.7	7.8	18.6	18.1	16.8	22.3	157	210
90	S1-241		91.2	92.7	6.3	7.3	19.2	17.8	17.4	23.9	158	220
91	S1-248		90.0	87.8	6.3	6.5	18.5	18.2	16.8	20.1	150	177
92	S1-101		81.2	84.3	6.3	7.2	18.4	18.8	18.1	22.0	146	184
93	S1-156		93.2	96.8	6.2	6.5	19.4	18.9	16.4	18.8	152	182
94	S1-113		90.3	95.2	5.0	6.3	20.3	18.1	14.1	18.8	126	179
95	S1-121		92.7	91.7	5.2	6.5	19.2	18.5	15.3	19.9	142	184
96	S1-122		87.7	94.0	7.3	6.8	19.0	18.1	17.7	21.2	155	199
97	S1-123		94.7	93.7	7.2	7.0	18.7	17.8	18.3	20.3	173	192
98	S1-124		94.3	94.0	6.8	7.7	18.5	17.9	19.4	23.0	182	217
99	S1-126		91.8	90.3	6.2	5.7	18.8	18.5	18.6	22.0	170	199
100	S1-149		88.3	86.5	6.0	6.0	18.0	17.8	16.3	18.8	144	163
		MEAN:	90.9	92.5	6.2	6.6	18.9	18.2	16.9	20.6	154	191

TABLE A9. ENTRY-TILLAGE MEANS FOR EXPERIMENT 2, FOR PS2, SK2, PI, SKI, AND PSKI

SET# 1

EN	ENNAME	NT PS2	FP PS2	NT SK2	FP SK2	NT PI	FP PI	NT SKI	FP SKI	NT PSKI	FP PSKI
--	------	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS
1	S1-3	95.4	91.4	98.6	92.5	6.0	4.8	5.4	4.2	3.0	1.1
2	S1-9	96.5	90.8	100.1	93.1	5.8	5.0	3.6	3.5	3.3	2.1
3	S1-41	95.5	93.8	96.9	92.5	4.6	5.3	3.9	2.7	1.4	-1.3
4	S1-47	91.5	91.5	94.1	92.9	4.5	5.8	4.3	4.7	2.3	1.4
5	S1-49	96.3	91.3	97.4	91.4	6.0	5.2	4.9	3.8	1.1	0.1
6	S1-53	94.6	91.6	99.0	94.8	5.1	5.4	4.5	5.4	4.0	3.1
7	S1-88	94.9	91.0	97.8	93.4	5.6	5.3	4.7	4.1	2.6	2.1
8	S1-89	94.5	91.9	96.1	93.4	5.1	4.0	4.3	3.5	1.6	1.3
9	S1-90	93.4	89.8	96.0	91.8	4.4	4.8	4.4	3.8	2.6	2.0
10	S1-91	96.5	93.0	97.5	93.9	6.1	3.9	4.8	3.8	1.2	0.7
11	S1-94	92.9	90.0	94.1	91.1	4.1	4.8	4.0	4.0	1.3	1.0
12	S1-97	95.6	91.9	97.6	93.6	5.4	4.4	4.4	3.2	2.0	1.8
13	S1-128	96.9	93.4	98.6	95.4	4.2	4.4	4.9	4.0	1.8	1.8
14	S1-129	98.1	93.4	100.5	95.3	7.1	5.6	4.0	5.9	2.3	1.7
15	S1-131	96.9	92.5	98.9	94.0	4.9	4.0	4.3	3.5	1.8	1.5
16	S1-135	94.0	91.5	95.4	91.3	4.6	4.0	4.9	4.0	1.4	-0.3
17	S1-136	94.9	91.6	96.4	92.3	5.6	4.5	4.9	4.4	1.6	0.6
18	S1-137	91.8	89.1	93.5	90.0	5.6	4.0	5.1	4.6	1.8	0.8
19	S1-148	93.8	88.9	97.3	91.1	5.3	4.5	5.4	4.0	3.5	2.4
20	S1-150	92.6	88.9	94.4	90.0	5.5	4.1	4.4	3.8	1.8	1.1
	MEAN:	94.8	91.3	97.0	92.7	5.3	4.7	4.6	4.0	2.1	1.3

TABLE A9 (CONTINUED)

EN	ENNAME		SET# 2 NT PS2 DAYS	FP PS2 DAYS	NT SK2 DAYS	FP SK2 DAYS	NT PI DAYS	FP PI DAYS	NT SKI DAYS	FP SKI DAYS	NT PSKI DAYS	FP PSKI DAYS
21	S1-151		93.5	90.1	95.4	92.4	4.6	3.4	4.8	5.0	1.9	2.3
22	S1-185		94.8	93.1	97.0	93.8	5.0	4.4	3.9	2.9	1.9	0.7
23	S1-192		98.3	95.5	100.8	98.1	3.9	3.9	3.5	3.1	2.5	2.6
24	S1-203		95.8	92.1	97.3	93.3	5.7	3.9	3.1	4.0	1.5	1.2
25	S1-204		95.0	91.4	97.3	93.5	4.8	4.2	4.6	3.9	2.3	2.0
26	S1-207		95.9	94.0	97.8	95.8	5.2	4.7	3.9	4.3	1.6	1.8
27	S1-208		93.5	91.3	95.4	92.6	4.8	5.3	4.7	4.3	1.9	1.4
28	S1-209		95.1	91.1	98.0	92.1	6.1	3.4	4.6	2.9	2.9	1.0
29	S1-213		98.1	95.5	100.5	98.0	4.5	3.8	3.8	3.4	2.4	2.3
30	S1-214		95.4	93.5	98.0	95.8	5.0	4.4	4.2	4.4	2.6	2.0
31	S1-219		95.4	91.9	98.5	94.5	5.2	4.3	4.6	5.0	3.0	2.3
32	S1-222		92.1	88.0	94.0	90.8	4.7	4.8	4.9	4.6	1.9	2.8
33	S1-224		92.0	88.8	95.0	90.6	4.4	4.6	4.8	4.4	3.0	1.7
34	S1-243		96.0	93.4	98.4	95.0	5.8	4.9	4.2	4.3	2.2	1.6
35	S1-251		95.5	91.5	98.4	93.6	5.6	4.4	5.0	4.3	2.9	2.1
36	S1-253		93.8	91.8	95.9	95.1	5.4	4.6	4.0	5.7	2.1	3.4
37	S1-258		95.5	91.5	97.6	92.6	4.3	4.1	3.4	3.4	2.1	1.1
38	S1-260		95.4	91.8	97.4	94.1	4.1	3.6	4.1	3.8	2.0	2.3
39	S1-265		95.1	91.5	97.5	92.9	4.4	4.0	4.1	2.6	2.3	1.7
40	S1-268		93.0	90.0	95.3	91.7	4.3	5.2	3.6	3.7	1.7	1.7
		MEAN:	94.9	91.9	97.3	93.8	4.9	4.3	4.2	4.0	2.2	1.9

TABLE A9 (CONTINUED)

SET# 3

EN	ENNAME		NT PS2 DAYS	FP PS2 DAYS	NT SK2 DAYS	FP SK2 DAYS	NT PI DAYS	FP PI DAYS	NT SKI DAYS	FP SKI DAYS	NT PSKI DAYS	FP PSKI DAYS
41	S1-1		93.5	89.5	94.3	91.8	5.0	4.5	4.2	3.5	0.8	1.8
42	S1-2		93.5	92.0	96.3	93.5	3.2	3.3	2.7	2.8	2.8	1.5
43	S1-7		95.5	93.8	97.3	94.5	4.3	3.0	2.8	2.8	1.8	0.8
44	S1-11		95.5	93.8	96.8	93.0	4.2	3.2	3.0	2.8	1.3	-0.8
45	S1-12		90.3	88.8	91.0	89.8	3.8	2.8	3.0	3.2	1.0	1.0
46	S1-14		97.8	95.0	98.8	96.0	4.3	3.2	2.3	2.7	1.0	1.0
47	S1-15		92.8	90.3	94.0	91.0	4.5	3.3	4.0	3.2	1.4	1.0
48	S1-17		91.5	91.0	94.0	92.3	4.0	3.3	3.0	2.7	2.4	1.3
49	S1-19		95.3	93.3	96.3	94.0	4.3	4.3	3.3	3.7	1.0	0.6
50	S1-22		89.0	88.5	91.8	89.5	4.3	3.3	3.7	3.0	2.2	0.8
51	S1-24		90.8	89.0	92.3	90.5	2.4	4.0	3.5	3.6	1.5	1.6
52	S1-25		93.5	90.8	94.0	91.0	4.2	3.4	3.3	3.3	0.5	0.2
53	S1-27		92.0	90.3	93.3	90.8	5.0	3.3	3.3	2.7	1.3	0.2
54	S1-29		89.0	89.8	91.8	90.5	4.0	3.2	3.0	3.2	2.6	0.8
55	S1-30		90.0	89.0	92.3	91.0	4.0	3.2	3.7	3.7	2.3	2.0
56	S1-32		92.0	89.5	95.0	92.0	3.8	3.8	4.0	3.6	2.8	2.5
57	S1-34		90.5	88.8	91.8	89.8	4.0	2.6	3.2	3.0	1.3	1.0
58	S1-35		91.8	90.3	92.3	91.5	3.8	3.0	3.7	3.0	0.4	1.3
59	S1-37		94.0	91.8	96.3	93.8	3.6	4.3	3.0	3.5	2.3	2.0
60	S1-40		90.3	89.3	92.8	93.3	3.0	4.2	4.3	3.7	2.5	4.0
		MEAN:	92.4	90.7	94.1	92.0	4.0	3.4	3.3	3.2	1.6	1.2

TABLE A9 (CONTINUED)

		SET# 4									
EN	ENNAME	NT PS2	FP PS2	NT SK2	FP SK2	NT PI	FP PI	NT SKI	FP SKI	NT PSKI	FP PSKI
		DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS
61	S1-44	93.8	91.8	96.8	93.3	4.5	3.6	3.3	2.5	3.0	1.6
62	S1-45	92.0	91.8	94.0	93.0	3.0	4.0	3.2	2.3	2.0	1.3
63	S1-46	91.0	92.0	93.3	93.3	3.0	3.8	4.6	2.4	1.8	1.3
64	S1-54	92.0	90.0	96.0	92.8	4.8	3.5	3.3	2.7	3.6	2.8
65	S1-56	92.8	94.0	95.5	95.3	4.3	4.2	3.0	2.5	2.5	1.3
66	S1-57	91.5	91.0	92.8	92.3	3.0	2.8	2.8	3.0	1.3	1.0
67	S1-59	89.5	89.8	90.8	92.0	3.3	3.2	3.3	4.4	1.0	2.0
68	S1-61	94.3	94.0	96.5	94.8	3.8	4.5	3.0	3.8	2.3	0.6
69	S1-64	92.5	90.3	92.5	92.0	3.0	3.3	2.5	2.8	0.4	1.8
70	S1-65	91.0	90.3	92.0	92.5	4.3	4.4	4.3	2.7	0.8	2.0
71	S1-69	95.8	94.3	97.3	95.5	4.5	4.2	3.0	2.2	1.5	1.3
72	S1-70	94.3	92.5	97.5	93.5	4.4	2.6	3.5	3.2	2.6	1.0
73	S1-72	89.5	89.5	92.0	91.0	3.4	2.5	3.0	3.4	2.5	1.5
74	S1-152	92.0	92.0	93.3	94.0	3.0	3.8	2.8	3.8	1.0	1.6
75	S1-153	92.8	92.0	95.0	93.8	4.0	3.8	2.8	3.0	1.6	1.4
76	S1-76	91.8	92.8	93.5	93.0	2.5	4.5	3.3	2.3	1.8	0.3
77	S1-77	93.5	92.3	95.0	94.0	3.4	5.0	3.2	3.8	1.6	1.8
78	S1-78	92.0	92.5	93.3	93.5	3.2	5.5	3.8	4.8	1.3	1.0
79	S1-81	93.0	91.0	95.8	93.5	4.2	4.3	3.3	3.0	2.8	2.0
80	S1-82	92.8	90.3	94.5	92.3	3.5	3.6	4.0	3.2	1.4	2.0
	MEAN:	92.4	91.7	94.3	93.3	3.6	3.8	3.3	3.1	1.8	1.5

TABLE A9 (CONTINUED)

EN	ENNAME		NT PS2	FP PS2	NT SK2	FP SK2	NT PI	FP PI	NT SKI	FP SKI	NT PSKI	FP PSKI
		SET# 5										
			DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS
81	S1-83		93.5	89.3	94.8	92.0	5.6	4.0	5.5	4.8	1.0	2.8
82	S1-86		97.0	94.8	97.5	95.3	3.5	4.0	2.8	2.8	0.5	0.5
83	S1-155		93.5	90.0	95.0	92.3	4.2	3.3	3.5	3.5	1.6	1.6
84	S1-95		93.0	90.0	96.8	92.0	5.4	2.8	2.8	2.8	3.8	2.0
85	S1-177		89.5	89.5	91.8	91.5	3.3	3.5	4.2	4.4	2.3	2.0
86	S1-182		89.8	89.0	91.3	91.0	3.5	3.3	3.2	3.3	1.5	1.6
87	S1-226		93.8	90.0	93.0	90.8	3.5	4.0	4.2	3.3	-0.3	0.8
88	S1-234		89.8	88.3	92.0	90.5	4.8	3.3	4.3	4.2	2.3	2.3
89	S1-237		93.3	90.5	95.0	91.8	3.2	3.6	3.3	3.7	1.8	1.3
90	S1-241		91.5	88.5	93.8	89.5	4.5	3.0	4.6	3.4	1.8	1.0
91	S1-248		89.8	89.8	91.0	91.5	3.0	4.0	2.8	4.4	1.3	1.8
92	S1-101		90.0	88.0	91.0	90.3	3.6	3.8	3.6	3.6	1.0	2.3
93	S1-156		90.5	90.0	92.5	92.5	3.2	3.2	4.3	3.8	1.6	2.5
94	S1-113		97.0	92.5	98.3	93.5	2.8	5.0	2.3	3.0	1.0	1.2
95	S1-121		98.0	94.3	99.8	96.0	3.0	2.8	2.3	3.2	1.8	1.8
96	S1-122		94.8	91.0	96.0	92.0	5.4	4.0	2.8	3.2	1.3	1.0
97	S1-123		91.0	90.0	94.0	92.5	3.0	4.8	3.5	2.8	2.6	2.0
98	S1-124		88.5	88.8	91.3	89.5	4.8	3.8	4.2	3.0	2.8	0.8
99	S1-126		91.0	89.5	92.5	91.5	4.3	3.0	3.8	3.8	1.5	2.0
100	S1-149		97.0	92.8	98.3	93.8	3.5	4.3	2.5	3.5	1.0	1.0
		MEAN:	92.6	90.3	94.3	92.0	3.9	3.7	3.5	3.5	1.6	1.6

TABLE A10. ENTRY-TILLAGE MEANS FOR EXPERIMENT 2, FOR PFI, SHI, PHTS, EHTS, AND EPHTS

SET# 1

EN	ENNAME	NT PFI	FP PFI	NT SHI	FP SHI	NT PHTS	FP PHTS	NT EHTS	FP EHTS	NT EPHTS	FP EPHTS
--	------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
						CM	CM	CM	CM	CM	CM
1	S1-3	-15.0	-6.8	116	348	14.5	13.4	13.0	11.3	3.9	5.2
2	S1-9	-12.1	-6.8	96	322	15.1	14.2	13.4	14.3	3.5	4.9
3	S1-41	-0.6	2.3	175	362	13.8	13.0	12.7	11.3	4.2	5.0
4	S1-47	-6.8	-2.9	148	311	13.3	16.1	11.5	13.6	3.7	5.0
5	S1-49	-7.8	-3.5	142	382	12.4	14.8	12.2	12.4	5.4	4.9
6	S1-53	-17.5	-14.4	104	294	15.6	16.6	12.7	14.9	3.6	4.9
7	S1-88	-7.0	-5.7	159	384	11.5	12.9	10.9	12.3	4.6	5.0
8	S1-89	-7.6	-0.3	160	390	14.3	15.6	12.6	14.5	4.6	5.2
9	S1-90	-16.2	-6.3	138	403	14.6	13.3	11.8	14.4	3.5	4.8
10	S1-91	-11.7	-3.1	134	373	14.2	12.4	14.6	12.1	3.8	3.9
11	S1-94	-8.2	-3.3	182	406	11.4	14.2	12.9	14.0	3.5	4.9
12	S1-97	0.5	1.0	182	385	11.5	14.0	11.6	9.9	3.9	5.3
13	S1-128	-12.6	-10.8	135	345	13.6	13.1	12.9	10.6	4.6	5.1
14	S1-129	-23.7	-6.2	104	332	14.0	13.6	12.2	13.9	4.4	4.7
15	S1-131	-7.3	0.4	168	402	14.3	13.8	11.0	11.1	4.3	5.1
16	S1-135	-6.7	1.4	144	361	12.1	12.7	11.1	10.2	4.5	5.6
17	S1-136	-5.6	-6.1	182	378	11.7	12.7	13.0	12.4	4.4	5.5
18	S1-137	-5.2	-3.4	174	396	18.7	15.2	13.9	11.1	4.2	5.1
19	S1-148	-7.0	-3.1	161	418	12.4	11.8	14.3	12.9	4.4	4.7
20	S1-150	-9.5	-6.8	181	399	13.1	13.2	9.4	9.2	3.8	3.8
	MEAN:	-9.4	-4.2	149	370	13.6	13.8	12.4	12.3	4.1	4.9

TABLE A10 (CONTINUED)

SET# 2

EN	ENNAME	NT PFI	FP PFI	NT SHI	FP SHI	NT PHTS CM	FP PHTS CM	NT EHTS CM	FP EHTS CM	NT EPHTS CM	FP EPHTS CM
21	S1-151	-4.4	-12.1	138	303	12.8	15.7	11.1	11.4	4.6	4.1
22	S1-185	-5.8	-0.2	183	379	16.4	15.0	12.4	12.0	3.4	4.2
23	S1-192	-9.6	-0.0	133	372	14.4	15.4	11.7	14.7	3.8	3.6
24	S1-203	-7.5	-9.1	179	355	12.0	12.9	10.5	11.8	3.2	3.9
25	S1-204	-7.5	-10.3	165	374	17.2	13.6	17.7	11.3	4.2	4.5
26	S1-207	-14.0	-9.2	112	298	12.0	15.5	9.6	11.7	4.5	4.8
27	S1-208	-3.1	-2.2	149	344	15.2	15.8	12.7	12.4	4.5	5.3
28	S1-209	-13.3	-9.0	69	224	16.7	12.7	11.9	14.5	5.0	5.4
29	S1-213	-16.6	-9.9	114	308	12.2	12.4	11.7	9.9	3.8	4.6
30	S1-214	-17.2	-5.1	153	372	13.1	12.4	12.5	11.6	4.2	4.2
31	S1-219	-1.4	4.8	170	422	14.7	11.2	11.0	13.2	4.2	5.0
32	S1-222	-11.8	-1.8	104	391	11.8	11.0	9.0	9.8	4.0	4.4
33	S1-224	-4.7	-6.7	172	343	13.6	11.8	11.2	10.5	3.0	4.3
34	S1-243	-5.6	2.5	170	385	15.7	13.6	12.9	10.3	4.1	5.9
35	S1-251	-6.9	2.0	168	409	14.3	15.2	12.9	10.6	4.1	6.1
36	S1-253	-3.7	-4.2	172	330	13.3	15.7	11.7	11.9	4.8	5.5
37	S1-258	-10.5	-1.6	149	383	12.2	14.2	11.0	11.8	3.9	3.8
38	S1-260	-10.3	1.1	147	377	15.9	14.5	13.8	15.3	3.8	5.0
39	S1-265	-23.1	-11.7	151	387	12.6	11.1	9.8	9.9	3.8	4.0
40	S1-268	-4.2	-0.5	147	396	12.9	14.6	12.1	10.8	4.1	4.7
	MEAN:	-9.1	-4.2	147	358	13.9	13.7	11.9	11.8	4.1	4.7

TABLE A10 (CONTINUED)

SET# 3

EN	ENNAME	NT PFI	FP PFI	NT SHI	FP SHI	NT PHTS CM	FP PHTS CM	NT EHTS CM	FP EHTS CM	NT EPHTS CM	FP EPHTS CM
41	S1-1	-6.6	2.9	146	406	11.9	13.8	12.7	13.2	2.8	3.2
42	S1-2	-15.4	-2.7	146	405	13.2	9.5	11.5	13.5	2.5	3.1
43	S1-7	-32.9	-32.0	64	214	10.7	14.1	11.6	12.1	2.4	3.3
44	S1-11	-12.8	-4.4	146	353	13.0	13.2	12.4	12.9	3.0	3.6
45	S1-12	-10.1	-7.9	149	341	17.6	16.6	14.7	13.6	2.8	2.6
46	S1-14	-29.9	-17.0	69	301	12.3	17.6	11.2	15.5	2.7	3.0
47	S1-15	-7.3	-2.8	200	420	11.2	15.1	12.4	14.8	2.8	2.9
48	S1-17	-19.8	-15.2	137	316	15.8	13.7	13.1	13.1	3.5	3.4
49	S1-19	-12.3	-10.0	161	348	9.2	10.2	11.8	10.0	3.7	3.5
50	S1-22	-15.7	-4.1	100	349	15.6	15.5	14.7	14.4	2.8	3.7
51	S1-24	-7.5	-6.2	208	425	14.1	16.4	11.1	13.3	2.8	3.5
52	S1-25	-23.5	-10.9	123	376	12.6	12.1	13.0	10.0	3.4	3.2
53	S1-27	-11.2	-8.1	162	383	16.3	13.7	13.3	9.8	3.5	3.3
54	S1-29	6.0	-4.4	233	392	15.4	12.8	13.7	12.4	3.2	3.5
55	S1-30	-23.1	-18.3	111	339	17.2	14.1	14.4	13.8	3.2	3.5
56	S1-32	-8.2	-6.2	178	372	11.3	16.9	13.4	15.7	2.9	3.2
57	S1-34	-26.9	-13.4	109	330	16.5	14.4	14.5	12.5	2.4	2.9
58	S1-35	-2.8	0.9	190	422	13.5	15.5	11.7	11.4	3.3	3.8
59	S1-37	-11.9	-0.8	172	408	16.5	19.2	13.4	12.9	4.1	3.6
60	S1-40	-15.9	-13.9	119	310	16.6	12.7	14.4	13.5	2.9	3.7
	MEAN:	-14.4	-8.7	146	361	14.0	14.4	12.9	12.9	3.0	3.3

TABLE A10 (CONTINUED)

SET# 4

EN	ENNAME	NT PFI	FP PFI	NT SHI	FP SHI	NT PHTS	FP PHTS	NT EHTS	FP EHTS	NT EPHTS	FP EPHTS
						CM	CM	CM	CM	CM	CM
61	S1-44	-30.1	-25.9	106	280	15.1	14.8	15.1	13.7	2.9	3.8
62	S1-45	-6.7	-15.0	163	326	14.5	14.8	11.2	11.8	3.6	3.9
63	S1-46	-12.8	-8.9	143	315	12.8	18.9	12.6	15.8	3.6	3.3
64	S1-54	-17.3	-13.3	160	330	11.1	16.4	14.9	14.5	3.3	4.6
65	S1-56	-35.8	-40.4	99	202	15.4	12.4	14.8	13.9	3.3	3.1
66	S1-57	-27.2	-18.6	89	288	15.6	19.3	15.5	17.5	3.4	2.5
67	S1-59	-17.8	-14.1	158	354	12.1	16.3	11.2	13.9	3.5	3.5
68	S1-61	-3.3	-7.3	172	349	14.0	15.1	16.5	15.0	2.9	3.4
69	S1-64	-2.9	-0.3	169	350	12.8	15.8	11.5	12.1	3.0	4.2
70	S1-65	-9.7	-8.8	157	325	15.8	19.8	15.1	16.1	2.7	3.1
71	S1-69	-24.0	-29.8	130	252	10.2	14.4	10.8	15.0	3.5	3.9
72	S1-70	-10.7	-5.8	133	357	13.0	14.2	14.2	12.1	2.5	2.6
73	S1-72	-15.0	-18.3	141	283	11.3	14.4	10.7	13.0	3.0	3.3
74	S1-152	-17.3	-15.1	152	310	17.2	14.1	16.3	15.1	3.4	3.7
75	S1-153	-38.7	-38.5	95	216	12.6	14.9	11.2	14.5	3.0	3.2
76	S1-76	-16.7	-15.8	120	277	13.5	15.5	11.9	13.3	3.0	3.4
77	S1-77	0.2	0.0	204	387	14.6	10.9	14.5	11.0	3.8	3.2
78	S1-78	-15.4	-9.6	148	313	16.0	17.7	12.4	12.3	3.7	3.5
79	S1-81	-12.4	-11.5	136	341	13.7	12.3	12.7	11.7	2.7	3.8
80	S1-82	-4.7	-5.7	180	385	12.7	15.3	11.7	15.8	2.9	4.6
	MEAN:	-15.9	-15.1	143	312	13.7	15.4	13.2	13.9	3.2	3.5

TABLE A10 (CONTINUED)

SET# 5

EN	ENNAME	NT PFI	FP PFI	NT SHI	FP SHI	NT PHTS	FP PHTS	NT EHTS	FP EHTS	NT EPHTS	FP EPHTS
						CM	CM	CM	CM	CM	CM
81	S1-83	-16.7	-8.7	133	359	16.2	14.6	14.7	14.3	3.4	3.3
82	S1-86	-35.8	-28.2	108	278	12.0	13.9	12.0	14.0	2.6	2.8
83	S1-155	-9.8	-11.6	143	342	16.5	16.3	12.9	13.5	3.5	4.1
84	S1-95	-16.1	-7.2	116	366	14.8	15.1	13.4	15.9	2.5	3.7
85	S1-177	-12.8	-18.2	191	356	12.1	12.8	10.4	11.5	3.9	3.7
86	S1-182	-14.5	-15.1	138	321	13.4	14.0	13.5	14.5	3.1	3.8
87	S1-226	-13.6	-8.6	167	350	11.6	16.9	15.6	14.7	3.5	3.1
88	S1-234	-18.7	-19.3	121	323	21.0	16.5	16.8	14.3	3.7	3.4
89	S1-237	-7.4	-8.1	154	378	10.3	10.8	12.4	10.8	2.8	3.4
90	S1-241	-18.7	-17.3	99	337	12.9	17.9	14.0	16.4	3.2	3.3
91	S1-248	1.3	-10.8	193	329	13.3	12.7	11.6	12.4	3.4	3.6
92	S1-101	-8.6	-13.5	181	333	18.6	22.2	14.7	16.0	2.8	3.2
93	S1-156	-24.1	-12.9	130	350	16.4	13.9	13.4	15.0	3.5	3.8
94	S1-113	-18.7	-27.0	94	281	14.1	14.4	12.8	14.5	3.4	3.6
95	S1-121	-29.0	-25.1	80	315	16.0	12.0	10.9	11.2	4.0	3.0
96	S1-122	-7.5	-16.7	165	335	16.6	19.3	16.6	18.1	3.6	3.2
97	S1-123	-5.1	-10.6	186	355	13.0	11.7	12.4	13.0	2.9	2.4
98	S1-124	-3.1	8.7	201	470	15.9	18.1	12.7	16.2	3.9	4.0
99	S1-126	-16.4	-22.9	143	316	14.1	16.0	15.5	13.5	3.6	4.0
100	S1-149	-26.1	-12.1	88	328	12.8	13.9	11.4	13.8	3.0	2.6
	MEAN:	-15.1	-14.3	141	341	14.6	15.1	13.4	14.2	3.3	3.4

TABLE A11. ENTRY-TILLAGE MEANS FOR EXPERIMENT 3, FOR GPMS, GPMSA, WPP, M, AND FST

SET# 1

EN	ENNAME	NT GPMS	FP GPMS	NT GPMSA	FP GPMSA	NT WPP	FP WPP	NT M	FP M	NT FST	FP FST
--	------	G/M2	G/M2	G/M2	G/M2	G	G	%	%	#/PLT	#/PLT
41	HOBART 1101	638	784	662	777	128.0	140.4	21.0	21.6	42.5	46.8
42	FRUNDT SX45A	738	821	782	839	151.6	159.4	20.5	21.0	41.1	44.0
43	CENEX 2114	874	909	861	901	168.4	164.3	22.3	22.0	44.6	46.3
44	GRUHN HYBRID SX7AA	720	795	758	794	150.5	144.5	20.2	20.4	41.5	46.6
45	MIDLAND M1051TY	637	757	632	746	119.6	133.1	20.6	18.2	44.8	47.6
46	ARMSTRONG SX61A	751	770	760	767	145.8	142.7	23.2	22.5	43.4	45.4
47	RENK RK66	726	837	721	838	136.0	151.8	20.9	20.0	44.6	46.4
48	FONTENELLE 420	710	740	724	756	138.1	140.1	21.6	21.3	43.0	45.1
49	GUTWEIN 2210	685	616	651	616	126.2	114.1	20.4	21.4	45.8	45.8
50	USS 0011	663	614	651	632	129.2	122.2	20.2	20.4	43.6	43.6
51	TALL CORN SX113	846	916	804	908	148.9	163.2	21.8	19.3	47.6	47.1
52	ENO SX16	857	713	819	717	152.6	129.8	19.7	20.4	47.0	46.6
53	CLAY CO 2239	577	609	576	620	115.0	117.5	19.9	19.2	43.0	43.8
54	HERMANN 2073	682	748	747	758	152.5	141.0	21.0	19.7	38.9	44.6
55	TRACY T2060	734	718	711	719	135.8	130.9	19.1	19.2	46.0	46.1
56	HORIZON 212	813	909	851	898	163.2	161.3	24.0	21.6	41.5	47.0
57	IOWA STATE M116	851	823	862	808	165.5	146.5	23.4	21.5	43.1	47.1
58	HOEGEMEYER SX2634	836	912	833	908	158.9	167.0	22.4	22.0	44.3	45.6
59	TROJAN T1058	629	712	662	719	135.9	137.7	20.9	20.0	38.8	43.6
60	WINTERSET SX43	728	731	705	726	135.6	131.1	20.3	19.3	45.8	46.8
	MEAN:	735	772	739	772	142.9	141.9	21.2	20.5	43.5	45.8

TABLE A11 (CONTINUED)

SET# 2

EN	ENNAME	NT GPMS	FP GPMS	NT GPMSA	FP GPMSA	NT WPP	FP WPP	NT M	FP M	NT FST	FP FST
--	------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
		G/M2	G/M2	G/M2	G/M2	G	G	%	%	#/PLT	#/PLT
61	FEDERAL FX8	740	874	689	881	135.4	162.9	19.6	19.5	46.1	45.3
62	LEADER SX630	837	902	807	903	153.0	163.3	23.9	22.4	46.0	46.6
63	MARTINSON SX440	685	807	674	801	130.0	140.7	20.1	20.8	44.9	48.1
64	GREAT LAKES 5922	745	930	784	936	156.3	170.2	22.8	21.4	41.0	46.1
65	PAYCO SX611	587	566	626	565	123.4	105.1	18.3	18.1	40.9	45.3
66	WYFFLES W21	660	786	668	775	134.8	136.9	20.1	19.9	42.4	48.0
67	SIEBEN 35XS	906	928	860	919	158.5	161.8	22.6	22.8	47.9	48.0
68	ACCO UC2990	592	779	582	778	110.5	142.4	20.1	19.4	45.1	46.1
69	O'S GOLD 6880	698	773	659	764	122.9	148.0	20.3	19.2	48.0	45.1
70	ASGROW RX511	636	702	650	709	126.5	128.6	20.0	19.4	42.9	46.0
71	AMERICANA 2600	707	710	703	709	135.3	127.1	18.8	18.2	44.1	47.0
72	FUNK G4315	642	716	652	712	124.4	127.2	18.8	19.1	43.5	47.3
73	SUPERCROST 2396	658	705	658	710	127.9	128.9	20.1	18.7	43.6	46.0
74	MIDDLEKOOP M301	775	853	746	850	144.1	153.1	22.5	20.4	45.5	46.9
75	JACOBSON JS19	653	732	692	734	130.0	131.6	20.8	18.9	41.5	47.0
76	GOLDEN HARVEST H2440	618	796	669	777	140.4	136.6	21.9	19.9	40.1	48.9
77	MCALLISTER SX7300	856	863	848	859	160.5	154.8	24.2	22.7	44.9	47.0
78	HICKORY GROVE HX3	618	690	583	691	112.0	125.7	19.0	19.1	46.5	46.0
79	KALTENGERG KX61	614	834	608	833	114.5	149.0	19.1	19.0	45.3	47.1
80	RENZE 6340	826	894	818	889	152.7	159.3	23.1	21.3	45.1	47.0
	MEAN:	703	792	699	790	134.7	142.7	20.8	20.0	44.3	46.7

TABLE A11 (CONTINUED)

SET# 3

EN	ENNAME	NT GPMS	FP GPMS	NT GPMSA	FP GPMSA	NT WPP	FP WPP	NT M	FP M	NT FST	FP FST
--	------	G/M2	G/M2	G/M2	G/M2	G	G	%	%	#/PLT	#/PLT
81	PFISTER 1700-1720	793	775	749	746	141.3	130.8	21.0	20.6	47.0	49.6
82	EMBRO X60	926	1009	908	1009	171.8	184.4	25.1	24.0	45.0	46.0
83	SAR SX123	566	680	560	681	107.7	122.6	19.8	19.2	44.9	46.6
84	SAR SX205	704	799	775	778	154.6	139.3	20.6	21.1	39.5	48.0
85	LYNKS LX4210	695	784	705	785	137.1	144.7	21.0	21.2	43.0	45.4
86	MIGRO HP277	577	712	639	718	128.7	132.4	20.2	19.1	38.9	45.3
87	PAG SX181	623	684	624	675	121.9	124.6	20.6	20.0	42.9	46.1
88	PIONEER 3780	615	708	585	704	112.7	125.7	19.5	18.8	45.8	47.3
89	PIONEER 3732	682	782	653	774	123.2	138.4	21.3	20.8	46.1	47.4
90	PIONEER 3901	598	585	591	612	115.4	113.4	19.2	18.5	43.6	43.9
91	PIONEER 3713	787	762	760	750	142.3	134.1	20.9	22.1	46.1	47.5
92	PIONEER 3541	777	806	750	808	139.6	147.2	22.0	20.4	46.6	46.3
93	NORTHRUP KING PX37	645	771	696	787	140.4	147.5	20.9	20.7	38.6	44.8
94	DEKALB XL25A	690	736	648	765	123.8	150.0	20.6	20.3	46.9	43.6
95	DEKALB XL54	732	807	728	810	139.0	149.9	24.4	22.6	44.3	45.5
96	CARGILL 862	673	725	666	718	129.9	131.1	19.7	21.0	44.0	46.6
97	JACQUES 7780	776	854	782	886	163.4	174.4	22.0	23.3	40.3	42.4
98	JACQUES JX177	733	802	736	802	140.2	142.9	21.8	20.8	43.8	47.3
99	DEKALB XL55A	832	921	829	922	159.0	166.2	21.4	20.1	43.8	46.8
100	PIONEER 3720	718	825	761	827	150.1	151.4	20.6	19.4	40.8	46.0
	MEAN:	707	776	707	778	137.1	142.6	21.1	20.7	43.6	46.1

TABLE A12. ENTRY-TILLAGE MEANS FOR EXPERIMENT 3, FOR PSL, PRL, PDE, PHT, EHT, AND SG

SET# 1

EN	ENNAME	NT PSL	FP PSL	NT PRL	FP PRL	NT PDE	FP PDE	NT PHT	FP PHT	NT EHT	FP EHT	NT SG	FP SG
--	------	%	%	%	%	%	%	CM	CM	CM	CM	1-9	1-9
41	HOBART 1101	18.7	11.7	0.0	0.8	0.0	0.5	185	190	79	86	3.5	3.0
42	FRUNDT SX45A	7.2	9.7	0.0	4.2	0.3	0.5	188	196	82	94	3.5	4.0
43	CENEX 2114	7.1	5.3	0.3	1.6	0.3	0.6	191	200	80	91	3.9	4.4
44	GRUHN HYBRID SX7AA	18.7	15.9	0.0	3.3	0.8	0.3	207	212	92	103	3.9	3.6
45	MIDLAND M1051TY	7.5	4.5	0.6	0.5	0.0	0.0	171	175	64	68	2.1	2.8
46	ARMSTRONG SX61A	8.4	8.2	0.0	3.8	0.2	0.3	193	208	88	100	4.3	4.4
47	RENK RK66	16.3	14.0	0.0	2.5	0.5	0.3	210	210	95	100	4.3	3.6
48	FONTENELLE 420	17.2	14.4	0.3	3.1	0.3	0.8	211	209	95	102	4.0	4.1
49	GUTWEIN 2210	8.1	7.4	0.8	0.5	0.0	0.2	167	165	58	57	1.9	2.3
50	USS 0011	22.2	12.1	1.4	1.2	0.0	0.3	184	196	71	78	1.9	1.9
51	TALL CORN SX113	9.5	8.7	0.0	2.7	0.3	0.0	198	205	84	97	3.6	4.4
52	ENO SX16	14.1	16.7	3.2	3.7	0.8	0.5	207	209	95	98	4.0	3.4
53	CLAY CO 2239	15.7	13.3	0.0	0.6	0.6	0.8	189	192	79	87	2.0	1.9
54	HERMANN 2073	20.6	20.5	1.9	3.7	0.0	0.3	212	210	98	103	3.8	3.0
55	TRACY T2060	22.5	20.7	0.0	2.5	1.0	0.0	209	209	103	106	3.3	2.1
56	HORIZON 212	6.1	4.5	2.0	3.7	0.0	0.0	197	208	84	97	4.3	4.4
57	IOWA STATE M116	5.5	4.2	0.3	1.6	0.0	1.3	194	197	82	92	5.3	4.1
58	HOEGEMEYER SX2634	10.2	5.8	0.3	1.8	0.5	0.6	204	212	92	103	4.5	3.9
59	TROJAN T1058	11.4	12.2	0.0	0.8	0.0	0.9	188	188	85	92	3.5	3.4
60	WINTERSET SX43	7.5	3.5	0.0	0.8	0.0	0.0	173	178	64	67	2.4	2.4
	MEAN:	12.7	10.7	0.5	2.2	0.3	0.4	194	198	84	91	3.5	3.3

TABLE A12 (CONTINUED)

SET# 2

EN	ENNAME	NT PSL	FP PSL	NT PRL	FP PRL	NT PDE	FP PDE	NT PHT	FP PHT	NT EHT	FP EHT	NT SG	FP SG
--	------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
		%	%	%	%	%	%	CM	CM	CM	CM	1-9	1-9
61	FEDERAL FX8	13.0	16.6	1.6	2.0	0.3	0.3	207	216	96	104	4.0	4.1
62	LEADER SX630	17.0	9.8	1.6	7.3	0.8	0.3	214	224	107	117	6.5	5.5
63	MARTINSON SX440	9.7	6.2	0.0	0.0	0.0	0.3	188	193	79	87	2.9	2.6
64	GREAT LAKES 5922	15.5	15.1	0.0	1.4	0.0	0.3	202	209	87	97	3.4	3.6
65	PAYCO SX611	9.6	18.1	0.0	1.1	0.0	1.4	181	194	75	85	2.0	2.5
66	WYFFLES W21	4.0	6.8	0.0	0.3	0.0	0.0	172	178	68	68	2.1	2.9
67	SIEBEN 35XS	4.7	5.3	0.0	1.8	0.0	0.8	195	196	85	91	3.5	3.8
68	ACCO UC2990	9.4	7.0	0.0	0.5	0.0	0.0	169	172	64	67	2.1	2.8
69	O'S GOLD 6880	4.7	8.4	0.0	1.0	0.0	0.3	170	178	65	68	2.6	2.6
70	ASGROW RX511	24.0	22.6	0.0	2.3	0.9	0.5	207	209	101	108	3.0	2.6
71	AMERICANA 2600	3.5	6.1	0.5	1.0	0.3	0.0	182	189	86	92	3.0	3.8
72	FUNK G4315	8.8	10.5	0.8	2.4	0.0	1.1	187	194	83	82	2.6	3.1
73	SUPERCROST 2396	7.7	9.4	0.0	1.2	0.3	1.3	185	191	79	87	2.8	3.0
74	MIDDLEKOOP M301	17.8	15.6	0.0	3.0	0.5	0.3	212	211	99	104	4.3	3.9
75	JACOBSON JS19	21.8	23.7	0.8	1.8	0.7	0.5	210	214	99	110	3.6	2.9
76	GOLDEN HARVEST H2440	8.3	7.1	0.0	1.1	1.4	0.3	182	183	71	74	3.3	2.9
77	MCALLISTER SX7300	14.6	17.7	0.8	1.2	0.5	0.8	219	220	108	115	4.5	4.1
78	HICKORY GROVE HX3	8.9	10.1	0.0	0.0	0.0	1.1	181	191	76	84	2.5	2.4
79	KALTENGERG KX61	5.1	3.1	0.0	0.6	0.0	0.5	167	179	63	70	2.0	2.5
80	RENZE 6340	5.7	5.5	1.1	2.9	0.0	0.0	192	197	82	85	3.5	4.5
	MEAN:	10.7	11.2	0.4	1.6	0.3	0.5	191	197	84	90	3.2	3.3

TABLE A12 (CONTINUED)

SET# 3

EN	ENNAME	NT PSL	FP PSL	NT PRL	FP PRL	NT PDE	FP PDE	NT PHT	FP PHT	NT EHT	FP EHT	NT SG	FP SG
		%	%	%	%	%	%	CM	CM	CM	CM	1-9	1-9
81	PFISTER 1700-1720	7.5	9.5	0.0	1.1	0.0	0.5	188	195	77	82	3.4	4.0
82	EMBRO X60	9.3	10.5	3.7	4.0	0.0	0.0	223	218	112	115	5.9	5.6
83	SAR SX123	12.9	14.5	0.3	0.3	0.3	0.3	180	183	75	80	3.0	2.8
84	SAR SX205	8.1	5.8	0.0	1.0	0.0	0.3	186	191	75	83	4.0	3.8
85	LYNKS LX4210	2.9	1.1	1.1	2.2	0.3	0.0	179	188	77	86	4.4	5.6
86	MIGRO HP277	6.7	8.1	0.0	0.6	0.0	0.0	186	190	86	94	4.3	3.9
87	PAG SX181	3.8	5.0	0.8	1.7	0.0	0.0	183	193	72	80	2.5	2.9
88	PIONEER 3780	11.5	12.7	0.3	0.0	0.0	0.5	178	190	75	84	2.9	2.9
89	PIONEER 3732	1.3	1.3	0.8	2.6	0.0	0.0	183	191	80	90	4.4	4.3
90	PIONEER 3901	12.4	13.0	0.8	1.4	0.3	0.3	185	191	81	88	2.0	1.4
91	PIONEER 3713	1.9	4.7	0.6	3.0	0.0	0.3	193	195	83	94	4.5	5.5
92	PIONEER 3541	1.9	3.0	0.0	5.4	0.5	0.3	190	201	79	93	4.8	4.3
93	NORTHRUP KING PX37	9.2	9.8	1.5	5.3	0.0	0.0	197	201	88	98	3.6	4.3
94	DEKALB XL25A	1.3	1.9	0.0	0.8	0.5	0.3	178	188	64	75	4.0	4.3
95	DEKALB XL54	7.4	4.7	7.0	8.0	0.0	0.0	186	195	79	89	3.6	3.8
96	CARGILL 862	8.5	8.2	0.3	1.4	0.0	0.8	194	206	81	94	4.1	4.6
97	JACQUES 7780	3.4	4.4	1.7	3.6	0.0	0.3	195	205	82	93	4.8	5.3
98	JACQUES JX177	13.7	13.9	3.8	1.8	0.3	0.3	209	207	96	102	4.1	4.4
99	DEKALB XL55A	13.1	14.2	0.6	0.3	0.0	0.3	209	215	94	103	4.9	4.0
100	PIONEER 3720	10.2	6.0	1.5	3.1	0.0	0.5	206	213	93	100	3.4	3.9
	MEAN:	7.3	7.6	1.2	2.4	0.1	0.2	191	198	82	91	3.9	4.1

TABLE A13. ENTRY-TILLAGE MEANS FOR EXPERIMENT 3, FOR PEM, EV, EMI, EPHT, AND BMPP

SET# 1

EN	ENNAME	NT PEM	FP PEM	NT EV	FP EV	NT EMI	FP EMI	NT EPHT	FP EPHT	NT BMPP	FP BMPP
		%	%	1-9	1-9	DAYS	DAYS	CM	CM	CM	CM
41	HOBART 1101	76.1	88.7	5.3	7.0	20.5	15.8	24.6	38.3	178	315
42	FRUNDT SX45A	69.9	80.8	4.8	6.3	19.7	16.3	23.0	34.3	143	256
43	CENEX 2114	77.3	82.7	4.6	6.4	21.8	16.5	24.2	34.0	176	265
44	GRUHN HYBRID SX7AA	77.2	89.6	5.4	6.9	20.3	16.9	25.8	38.5	188	328
45	MIDLAND M1051TY	77.5	91.7	4.9	7.4	18.9	16.3	23.5	40.5	169	356
46	ARMSTRONG SX61A	70.8	81.1	4.1	5.8	22.7	16.8	19.5	30.8	129	232
47	RENK RK66	80.6	88.6	4.5	6.5	21.1	15.9	22.9	39.0	173	324
48	FONTENELLE 420	77.5	83.6	4.3	5.6	21.3	17.2	23.4	37.0	165	286
49	GUTWEIN 2210	78.0	83.2	4.9	6.4	21.7	16.5	26.1	34.8	190	268
50	USS 0011	66.7	73.9	3.5	5.1	25.1	18.5	23.2	36.9	145	258
51	TALL CORN SX113	83.2	91.6	5.5	6.3	18.8	16.3	23.4	33.5	185	291
52	ENO SX16	85.6	86.7	6.1	7.0	20.8	16.6	26.5	39.2	214	319
53	CLAY CO 2239	73.2	82.4	4.8	7.0	19.7	16.4	26.2	38.8	177	302
54	HERMANN 2073	67.7	80.8	5.1	7.1	18.9	16.4	23.2	38.2	147	292
55	TRACY T2060	82.6	91.3	5.0	7.0	21.4	15.8	25.0	35.2	194	304
56	HORIZON 212	65.8	83.6	4.8	6.1	18.6	16.6	20.5	32.6	134	258
57	IOWA STATE M116	74.2	90.5	4.5	6.0	21.8	17.0	20.5	32.3	143	279
58	HOEGEMEYER SX2634	81.6	88.7	5.0	6.4	21.5	15.8	23.3	35.3	177	292
59	TROJAN T1058	65.0	78.7	3.9	6.1	23.1	16.8	23.3	35.9	142	265
60	WINTERSET SX43	80.5	88.2	4.9	6.5	20.8	16.4	24.7	40.7	185	338
	MEAN:	75.5	85.3	4.8	6.4	20.9	16.5	23.6	36.3	168	291

TABLE A13 (CONTINUED)

SET# 2

EN	ENNAME	NT PEM	FP PEM	NT EV	FP EV	NT EMI	FP EMI	NT EPHT	FP EPHT	NT BMPP	FP BMPP
--	------	%	%	1-9	1-9	DAYS	DAYS	CM	CM	CM	CM
61	FEDERAL FX8	78.7	85.1	4.4	6.1	20.0	16.3	25.4	37.4	192	300
62	LEADER SX630	80.5	89.6	5.5	6.9	20.9	16.0	24.6	37.0	183	316
63	MARTINSON SX440	83.0	87.7	4.9	7.0	20.8	15.7	23.9	39.9	185	330
64	GREAT LAKES 5922	70.1	82.4	4.8	6.3	21.0	16.4	23.1	37.2	147	282
65	PAYCO SX611	72.8	88.6	4.3	6.4	22.0	16.2	24.1	37.6	157	327
66	WYFFLES W21	75.1	86.1	5.0	6.8	21.1	15.7	25.6	38.0	180	308
67	SIEBEN 35XS	89.7	94.9	5.4	6.3	22.1	17.9	21.6	32.1	187	292
68	ACCO UC2990	79.1	89.8	4.6	6.5	20.9	16.7	24.5	36.2	188	306
69	O'S GOLD 6880	87.1	93.6	6.3	6.9	18.6	16.8	26.8	39.0	218	347
70	ASGROW RX511	78.4	88.4	4.8	6.4	22.9	16.6	24.0	36.5	178	311
71	AMERICANA 2600	84.6	91.0	5.5	6.9	22.1	16.2	24.6	38.0	198	330
72	FUNK G4315	76.4	91.1	5.0	7.1	22.5	16.4	24.9	40.6	176	350
73	SUPERCROST 2396	82.7	89.4	5.1	7.4	20.9	16.6	28.5	38.9	219	327
74	MIDDLEKOOP M301	83.5	87.5	5.4	6.6	22.6	17.0	26.2	39.4	206	327
75	JACOBSON JS19	66.6	83.4	4.8	6.8	22.9	17.1	23.3	38.1	150	303
76	GOLDEN HARVEST H2440	70.2	89.8	4.3	6.8	20.3	15.9	22.7	38.1	150	324
77	MCALLISTER SX7300	82.2	93.9	4.8	7.1	23.6	16.7	21.1	34.4	162	311
78	HICKORY GROVE HX3	88.6	92.7	5.4	6.6	20.4	15.9	28.9	37.1	244	327
79	KALTENGERG KX61	79.3	85.3	5.6	6.5	19.1	15.8	26.1	36.5	191	297
80	RENZE 6340	77.3	89.3	5.4	7.1	20.0	16.6	22.8	36.0	165	307
	MEAN:	79.3	89.0	5.0	6.7	21.2	16.4	24.6	37.4	184	316

TABLE A13 (CONTINUED)

EN	ENNAME	NT PEM	FP PEM	NT EV	FP EV	NT EMI	FP EMI	NT EPHT	FP EPHT	NT BMPP	FP BMPP
	SET# 3										
		%	%	1-9	1-9	DAYS	DAYS	CM	CM	CM	CM
81	PFISTER 1700-1720	79.3	89.7	5.0	6.1	20.8	16.0	26.0	37.0	197	317
82	EMBRO X60	78.1	90.6	5.0	6.9	20.6	17.1	22.3	34.7	163	298
83	SAR SX123	82.4	90.5	4.6	7.4	22.2	16.5	23.8	40.6	195	347
84	SAR SX205	67.1	84.1	4.4	6.4	21.9	16.7	24.1	37.9	150	297
85	LYNKS LX4210	70.6	76.6	4.9	6.5	20.8	16.8	24.5	39.8	159	286
86	MIGRO HP277	63.9	78.0	4.3	6.8	21.0	16.2	22.6	40.1	136	299
87	PAG SX181	77.4	88.0	5.0	6.5	23.3	16.9	25.8	38.4	191	320
88	PIONEER 3780	79.4	89.5	5.1	6.9	22.1	16.8	27.3	39.5	204	336
89	PIONEER 3732	78.9	91.3	6.0	7.4	22.3	17.4	25.3	42.0	194	361
90	PIONEER 3901	79.4	83.3	5.0	6.6	21.8	16.6	28.8	44.7	224	346
91	PIONEER 3713	83.4	92.4	5.6	6.3	22.5	17.8	24.8	34.9	193	308
92	PIONEER 3541	81.4	88.9	4.5	6.5	21.5	16.3	21.6	35.8	160	302
93	NORTHRUP KING PX37	71.1	83.0	4.3	6.5	22.2	16.6	24.1	38.2	163	302
94	DEKALB XL25A	86.2	88.5	5.4	7.0	22.9	17.0	26.7	37.4	217	310
95	DEKALB XL54	79.4	90.5	4.5	6.1	20.6	16.9	23.7	33.5	177	286
96	CARGILL 862	78.5	87.1	4.4	5.9	21.3	17.2	26.3	34.9	193	287
97	JACQUES 7780	63.6	74.3	4.0	5.3	22.9	16.3	21.8	29.6	130	201
98	JACQUES JX177	74.7	88.8	4.3	6.5	23.0	17.2	22.6	39.0	160	329
99	DEKALB XL55A	82.7	91.7	6.1	7.8	20.8	17.5	28.0	41.9	217	368
100	PIONEER 3720	62.0	76.4	4.3	6.3	22.5	17.9	24.8	41.3	142	294
	MEAN:	76.0	86.2	4.8	6.6	21.8	16.9	24.8	38.1	178	310

TABLE A14. ENTRY-TILLAGE MEANS FOR EXPERIMENT 3, FOR PS2, SK2, PI, SKI, AND PSKI

SET# 1

EN	ENNAME	NT PS2	FP PS2	NT SK2	FP SK2	NT PI	FP PI	NT SKI	FP SKI	NT PSKI	FP PSKI
--	------	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS
41	HOBART 1101	89.8	84.5	90.5	86.3	4.3	4.3	3.8	4.0	1.3	1.8
42	FRUNDT SX45A	89.5	87.0	89.3	86.7	4.2	4.5	3.2	3.5	-0.5	-0.5
43	CENEX 2114	92.2	88.8	92.5	87.8	4.7	4.8	4.7	4.0	0.3	-1.0
44	GRUHN HYBRID SX7AA	91.7	88.3	91.2	89.2	4.8	4.2	4.8	4.3	-0.8	1.3
45	MIDLAND M1051TY	87.7	84.2	88.7	84.2	3.8	4.7	4.2	4.3	1.3	0.0
46	ARMSTRONG SX61A	92.8	92.3	93.7	89.8	5.2	7.0	7.8	4.3	0.8	-3.0
47	RENK RK66	92.3	86.0	94.0	87.5	2.7	3.3	5.2	3.8	1.5	2.0
48	FONTENELLE 420	92.0	88.2	92.5	87.8	4.5	4.3	4.8	4.2	0.5	0.3
49	GUTWEIN 2210	85.8	83.7	87.0	85.3	4.8	4.7	5.0	4.0	1.0	2.0
50	USS 0011	90.2	85.3	90.3	87.7	4.8	3.3	4.0	5.5	0.0	3.3
51	TALL CORN SX113	91.5	88.8	90.3	89.3	4.5	4.3	4.2	3.0	-1.8	0.5
52	ENO SX16	90.2	86.2	91.8	88.0	4.7	3.3	5.8	2.5	1.8	2.3
53	CLAY CO 2239	88.5	84.3	89.2	84.8	4.7	3.7	5.2	3.8	0.5	1.0
54	HERMANN 2073	92.3	86.7	92.8	86.2	4.2	3.7	5.5	3.5	0.8	-0.8
55	TRACY T2060	92.3	88.2	92.7	88.0	4.3	4.5	5.8	2.5	0.5	-0.3
56	HORIZON 212	92.5	86.8	92.8	87.8	5.0	5.2	5.3	3.7	0.0	1.5
57	IOWA STATE M116	92.2	89.2	93.5	89.2	3.8	5.5	5.3	3.5	1.8	0.0
58	HOEGEMEYER SX2634	92.5	87.5	94.0	87.8	4.3	4.2	6.2	3.2	1.8	0.5
59	TROJAN T1058	89.2	84.3	90.2	84.8	4.8	4.0	5.7	4.0	1.3	0.5
60	WINTERSET SX43	87.3	84.8	88.2	85.2	4.3	3.8	3.3	3.2	1.0	0.8
	MEAN:	90.6	86.8	91.3	87.2	4.4	4.4	5.0	3.7	0.6	0.6

TABLE A14 (CONTINUED)

SET# 2

EN	ENNAME	NT PS2	FP PS2	NT SK2	FP SK2	NT PI	FP PI	NT SKI	FP SKI	NT PSKI	FP PSKI
--	------	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS
61	FEDERAL FX8	96.0	91.8	93.7	87.7	4.3	4.8	5.0	4.3	-0.3	-4.3
62	LEADER SX630	93.7	90.0	96.0	91.3	6.3	3.8	5.5	3.2	3.5	1.5
63	MARTINSON SX440	88.7	85.5	89.5	86.7	4.5	3.3	4.0	3.7	1.3	1.3
64	GREAT LAKES 5922	90.5	87.8	90.5	87.5	5.3	5.8	6.2	3.7	0.0	-0.5
65	PAYCO SX611	88.2	85.2	88.8	85.7	5.3	3.3	3.8	4.3	1.5	0.5
66	WYFFLES W21	87.0	83.8	88.0	85.7	3.2	2.7	3.2	3.3	1.3	2.3
67	SIEBEN 35XS	91.0	89.3	91.7	89.2	4.3	3.3	4.5	4.0	0.5	-0.8
68	ACCO UC2990	86.7	83.5	88.7	85.0	4.3	3.7	3.7	3.8	2.3	2.0
69	O'S GOLD 6880	85.8	84.7	87.5	85.5	3.3	5.0	4.5	3.5	2.3	1.8
70	ASGROW RX511	92.8	89.7	93.5	88.7	5.7	4.8	5.5	3.5	1.0	-1.3
71	AMERICANA 2600	88.5	85.7	89.0	85.5	3.8	3.2	4.3	2.8	0.8	0.0
72	FUNK G4315	89.3	83.7	88.7	84.3	5.5	4.2	5.3	3.7	-1.3	0.8
73	SUPERCROST 2396	87.3	83.8	88.2	85.2	3.8	3.0	3.7	4.8	0.8	2.0
74	MIDDLEKOOP M301	91.0	86.3	92.8	87.5	3.8	3.2	4.8	3.7	1.8	1.3
75	JACOBSON JS19	91.8	87.3	92.2	88.2	4.7	3.3	5.5	4.3	0.0	1.0
76	GOLDEN HARVEST H2440	89.5	83.7	90.2	86.2	5.5	3.7	5.2	5.3	1.0	3.3
77	MCALLISTER SX7300	95.8	91.8	97.7	91.0	5.5	4.7	4.8	3.5	2.3	-0.5
78	HICKORY GROVE HX3	86.3	85.2	86.8	85.3	4.8	4.3	3.2	3.7	0.8	-0.5
79	KALTENGERG KX61	86.0	83.7	87.2	84.5	3.8	3.8	3.8	3.7	1.0	0.8
80	RENZE 6340	89.7	85.7	90.5	87.8	4.3	3.0	4.5	3.3	1.0	2.8
	MEAN:	89.8	86.4	90.5	86.9	4.6	3.8	4.5	3.8	1.1	0.7

TABLE A14 (CONTINUED)

SET# 3

EN	ENNAME	NT PS2	FP PS2	NT SK2	FP SK2	NT PI	FP PI	NT SKI	FP SKI	NT PSKI	FP PSKI
--	------	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS	DAYS
81	PFISTER 1700-1720	89.5	84.2	90.8	86.2	4.2	3.8	4.8	4.8	1.3	2.0
82	EMBRO X60	93.8	89.3	95.5	89.0	5.2	5.3	5.5	4.2	1.8	-1.0
83	SAR SX123	89.8	83.8	90.3	84.7	4.5	3.5	5.7	3.3	0.0	0.5
84	SAR SX205	88.7	84.8	89.3	85.7	4.7	4.0	5.2	3.8	0.5	1.3
85	LYNKS LX4210	89.5	85.0	89.7	86.0	5.2	3.7	4.2	4.0	0.5	1.0
86	MIGRO HP277	89.0	84.3	89.3	84.3	4.2	3.8	4.3	4.7	0.3	0.0
87	PAG SX181	87.3	83.5	88.0	85.0	5.3	4.7	4.8	4.2	0.8	2.0
88	PIONEER 3780	88.0	84.3	88.7	85.8	4.8	4.2	4.5	3.7	0.5	2.3
89	PIONEER 3732	88.7	83.0	89.8	83.7	4.7	3.2	4.0	3.5	1.8	0.5
90	PIONEER 3901	88.0	83.5	88.7	84.2	4.7	3.8	5.0	4.7	1.0	1.3
91	PIONEER 3713	87.0	85.0	88.8	87.0	4.3	3.2	5.2	4.0	2.0	2.8
92	PIONEER 3541	89.8	85.3	89.8	86.7	4.2	3.5	4.3	3.5	0.0	1.5
93	NORTHRUP KING PX37	91.0	86.5	91.8	87.2	6.8	3.7	7.3	4.3	1.0	0.8
94	DEKALB XL25A	87.5	83.7	89.2	85.5	3.7	4.8	3.7	3.5	1.5	2.5
95	DEKALB XL54	88.5	84.7	89.2	85.8	4.5	3.0	3.8	3.3	0.8	1.5
96	CARGILL 862	87.8	85.2	88.5	87.7	4.8	5.3	5.8	5.2	1.0	3.5
97	JACQUES 7780	92.3	88.0	92.5	88.7	6.0	4.3	6.3	4.3	0.3	1.0
98	JACQUES JX177	93.2	86.5	94.5	88.0	5.3	2.8	5.2	3.2	1.0	2.0
99	DEKALB XL55A	90.8	85.2	91.7	86.8	3.7	4.0	4.5	3.7	0.0	1.5
100	PIONEER 3720	89.7	85.2	90.7	84.3	4.5	4.3	5.5	4.2	0.8	-1.3
	MEAN:	89.5	85.0	90.3	86.1	4.8	3.9	5.0	4.0	0.8	1.3

TABLE A15. ENTRY-TILLAGE MEANS FOR EXPERIMENT 3, FOR PFI, PHTS, EHTS, AND EPHTS

SET# 1

EN	ENNAME	NT PFI	FP PFI	NT PHTS	FP PHTS	NT EHTS	FP EHTS	NT EPHTS	FP EPHTS
--	------	-----	-----	-----	-----	-----	-----	-----	-----
				CM	CM	CM	CM	CM	CM
41	HOBART 1101	28.3	34.6	12.2	10.4	10.1	10.0	5.4	6.7
42	FRUNDT SX45A	41.0	39.8	11.8	12.9	10.0	8.2	5.9	5.1
43	CENEX 2114	45.6	44.9	10.6	12.1	10.8	9.1	4.2	6.3
44	GRUHN HYBRID SX7AA	36.2	35.3	16.1	12.2	12.2	11.0	7.1	5.3
45	MIDLAND M1051TY	29.4	37.3	12.0	9.6	9.1	7.9	5.5	6.1
46	ARMSTRONG SX61A	36.9	33.8	17.9	15.7	15.6	14.9	5.4	5.7
47	RENK RK66	33.5	39.5	7.5	12.0	8.2	8.8	6.1	5.6
48	FONTENELLE 420	32.8	32.3	10.7	13.3	12.1	9.9	5.7	7.2
49	GUTWEIN 2210	30.8	24.4	11.9	12.8	8.8	10.2	5.7	6.8
50	USS 0011	26.8	25.0	10.7	12.1	10.8	11.1	4.8	6.8
51	TALL CORN SX113	41.1	46.6	11.7	9.9	9.6	9.9	4.3	4.8
52	ENO SX16	41.8	29.6	13.9	12.8	10.8	9.9	6.2	5.8
53	CLAY CO 2239	23.5	24.8	9.4	9.6	9.0	11.5	6.3	6.5
54	HERMANN 2073	33.8	32.0	11.4	12.6	11.6	11.6	5.9	5.1
55	TRACY T2060	32.4	29.7	9.2	9.7	11.1	8.6	6.0	6.0
56	HORIZON 212	43.5	45.0	13.0	12.0	12.9	10.6	5.1	6.4
57	IOWA STATE M116	45.2	38.8	9.5	11.3	8.2	9.4	4.0	5.1
58	HOEGEMEYER SX2634	42.4	45.2	9.4	13.0	7.9	8.7	3.5	5.3
59	TROJAN T1058	30.5	31.6	10.7	9.5	10.0	7.9	5.9	7.3
60	WINTERSET SX43	35.3	35.2	8.8	10.3	8.3	9.5	5.2	5.3
	MEAN:	35.5	35.3	11.4	11.7	10.4	9.9	5.4	6.0

TABLE A15 (CONTINUED)

SET# 2

EN	ENNAME	NT PFI	FP PFI	NT PHTS	FP PHTS	NT EHTS	FP EHTS	NT EPHTS	FP EPHTS
--	------	-----	-----	-----	-----	-----	-----	-----	-----
				CM	CM	CM	CM	CM	CM
61	FEDERAL FX8	32.7	42.3	12.6	13.4	11.5	10.4	5.2	6.1
62	LEADER SX630	37.1	42.9	9.6	6.9	9.5	8.6	5.5	4.5
63	MARTINSON SX440	32.4	38.5	11.4	9.9	10.5	10.2	5.5	4.9
64	GREAT LAKES 5922	37.0	45.1	11.0	9.8	9.4	8.2	6.1	5.1
65	PAYCO SX611	30.3	20.3	11.2	8.6	10.6	9.3	4.7	5.9
66	WYFFLES W21	33.6	37.3	8.9	10.0	9.7	8.9	5.5	5.0
67	SIEBEN 35XS	46.1	45.5	9.2	9.3	9.6	7.7	4.8	3.7
68	ACCO UC2990	25.6	37.8	9.4	11.9	9.7	8.3	5.0	6.1
69	O'S GOLD 6880	32.7	36.5	11.4	7.2	11.7	8.5	5.2	5.8
70	ASGROW RX511	26.6	28.2	12.4	7.2	10.3	8.3	5.1	5.3
71	AMERICANA 2600	37.3	34.1	10.2	10.1	9.9	9.4	5.1	5.9
72	FUNK G4315	32.0	32.1	14.5	13.4	10.9	12.4	5.8	5.2
73	SUPERCROST 2396	31.8	32.7	12.3	8.9	10.1	10.1	5.0	6.0
74	MIDDLEKOOP M301	33.7	39.5	12.1	9.8	7.3	10.3	5.3	7.1
75	JACOBSON JS19	29.7	30.1	16.4	11.3	12.8	10.2	5.1	5.4
76	GOLDEN HARVEST H2440	31.1	37.2	18.2	16.1	15.9	15.3	5.6	5.2
77	MCALLISTER SX7300	40.9	37.8	12.4	8.8	10.4	10.2	4.5	6.5
78	HICKORY GROVE HX3	26.6	30.9	10.8	8.5	9.2	10.3	4.8	4.9
79	KALTENGERG KX61	29.6	43.2	9.2	9.0	9.2	11.2	6.1	6.2
80	RENZE 6340	41.9	44.4	8.6	11.3	8.7	8.4	4.5	5.2
	MEAN:	33.4	36.8	11.6	10.1	10.3	9.8	5.2	5.5

TABLE A15 (CONTINUED)

SET# 3

EN	ENNAME	NT PFI	FP PFI	NT PHTS	FP PHTS	NT EHTS	FP EHTS	NT EPHTS	FP EPHTS
--	------	-----	-----	-----	-----	-----	-----	-----	-----
				CM	CM	CM	CM	CM	CM
81	PFISTER 1700-1720	38.1	33.7	11.2	10.8	11.0	9.1	5.3	4.7
82	EMBRO X60	45.7	49.3	9.3	10.0	10.1	10.4	5.1	6.2
83	SAR SX123	23.1	28.9	11.6	11.5	11.2	11.8	5.3	5.5
84	SAR SX205	40.2	36.7	15.5	11.8	12.6	12.1	4.9	6.2
85	LYNKS LX4210	35.9	38.4	11.4	9.0	10.6	10.1	6.5	5.0
86	MIGRO HP277	30.6	33.5	10.2	9.8	8.5	11.3	6.2	4.9
87	PAG SX181	29.8	30.4	11.0	12.3	9.5	11.4	5.6	6.0
88	PIONEER 3780	25.6	31.4	9.8	10.0	10.5	9.8	5.2	6.4
89	PIONEER 3732	32.1	37.8	8.9	7.8	10.2	8.1	4.9	6.3
90	PIONEER 3901	26.0	24.8	11.1	10.0	8.3	9.0	6.1	7.7
91	PIONEER 3713	40.5	34.0	11.3	9.4	10.4	8.0	6.1	5.6
92	PIONEER 3541	39.0	39.8	8.9	10.2	9.3	11.2	4.5	5.1
93	NORTHRUP KING PX37	33.4	36.1	14.1	14.1	11.9	8.8	5.7	6.5
94	DEKALB XL25A	32.4	37.5	13.6	12.3	9.8	10.0	5.7	5.6
95	DEKALB XL54	32.5	37.5	9.4	8.4	8.5	8.4	5.7	6.2
96	CARGILL 862	32.4	31.7	11.7	11.0	9.8	10.2	7.1	8.0
97	JACQUES 7780	40.6	42.8	11.4	10.6	9.1	12.2	5.3	7.0
98	JACQUES JX177	33.9	36.3	9.0	9.8	9.0	8.3	5.3	4.8
99	DEKALB XL55A	42.2	45.5	10.2	9.1	8.9	7.8	6.0	4.3
100	PIONEER 3720	38.2	41.3	10.8	12.2	7.1	11.6	6.1	7.7
	MEAN:	34.6	36.4	11.0	10.5	9.8	10.0	5.6	6.0